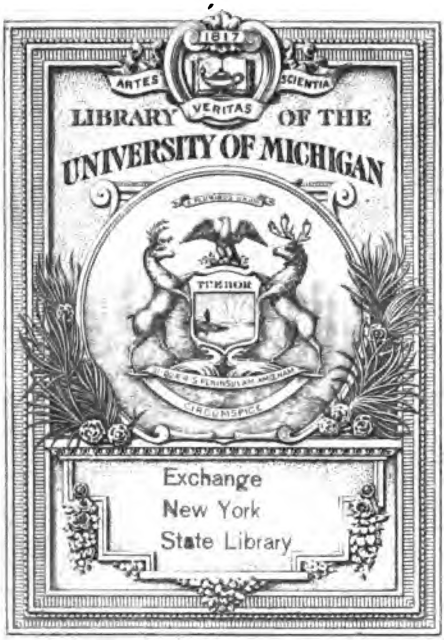
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ONE HUNDRED AND FORTY-SECOND SESSION

1919

VOL. XXII — NO. 59, PART 5

ALBANY
J. B. LYON COMPANY, PRINTERS
1919

Legislative Document — No. 59

STATE OF NEW YORK

THIRTY-SEVENTH ANNUAL REPORT

OF THE

New York Agricultural Experiment Station.

(GENEVA, ONTARIO COUNTY)

For the Year 1918.

With Reports of Director and Other Officers.

ALBANY
J. B. LYON COMPANY, PRINTERS
1919

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 15, 1919.

To the Legislature of the State of New York:

As Commissioner of Agriculture, and as President of the Board of Control, I have the honor to submit herewith the Thirty-seventh Annual Report of the Director of the New York Agricultural Experiment Station, at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,
CHARLES S. WILSON,
Commissioner.

NEW YORK AGRICULTURAL EXPERIMENT STATION.

W. H. JORDAN, *Director*.

GENEVA, N. Y., *January* 15, 1919.

HON. CHARLES S. WILSON, *Commissioner of Agriculture, Albany, N. Y.*:

DEAR SIR: I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1918.

Yours respectfully,
W. H. JORDAN,
Director.

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JAMES E. MENSCHING, M.S., *Associate Chemist (Agronomy).*

†WILLIAM W. BAER, B.S., *Assistant Chemist (Soils).*

[1]EVERETT P. REED, B.S. A.,
[2]JAMES D. HARLAN, B.S., *Assistant Agronomists.*

WILLIAM P. WHEELER, *First Assistant (Animal Industry).*

ROBERT S. BREED, PH.D., *Bacteriologist.*
HAROLD J. CONN, PH.D., *Associate Bacteriologist.*

[3]GODFREY L. A. RUEHLE,
JOHN W. BRIGHT, M.S., *Assistant Bacteriologists.*

FRED C. STEWART, M.S., *Botanist.*
WALTER O. GLOYER, M.A., *Associate Botanist.*

MANCEL T. MUNN, M.S., *Assistant Botanist.*

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†RUDOLPH J. ANDERSON, B.S.,
ARTHUR W. CLARK, B.S.,
JOHN C. BAKER, PH.D., *Associate Chemists.*

MORGAN P. SWEENEY, M.A.,
OTTO MCCREARY, B.S.,
RICHARD F. KEELER, A.B.,
WILLIAM F. WALSH, B.S.,
WALTER L. KULP, M.S., *Assistant Chemists.*

GEORGE A. SMITH, *Dairy Expert*
FRANK H. HALL, B.S., *Vice-Director; Editor and Librarian.*

PERCIVAL J. PARROTT, M.A., *Entomologist.*

HUGH GLASGOW, PH.D.,
*FRED Z. HARTZELL, M.A., (Fredonia), *Associate Entomologists.*

HAROLD E. HODGKISS, B.S,
BENTLEY B. FULTON, M.S., *Assistant Entomologists.*

ULYSSES P. HEDRICK, Sc.D., *Horticulturist.*

ROY D. ANTHONY, M.S.A.,
*FRED E. GLADWIN, B.S. (Fredonia),
ORRIN M. TAYLOR, *Associate Horticulturists.*

†GEORGE H. HOWE, B.S.A.,
JOSEPH W. WELLINGTON, B.S.,
WILLIAM C. STONE, M.S.,
[4]EDWARD H. FRANCIS, M. A., *Assistant Horticulturists.*

F. ATWOOD SIRRINE M.S., (Riverhead), *Special Agent.*

JESSIE A. SPERRY, *Director's Secretary.*
FRANK E. NEWTON,
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LENA G. CURTIS,
MAE M. MELVIN,
MAUDE L. HOGAN,
K. LORAINE HORTON, *Clerks and Stenographers.*

ELIZABETH JONES, *Computer and Mailing Clerk.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

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* Connected with Grape Culture Investigations. † On leave in war service.
[1] Resigned February 28, 1918.
[2] Appointed April 15, 1918.
[3] Resigned June 30, 1918.
[4] Appointed May 1, 1918.

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THIRTY-SEVENTH ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

GENEVA, N. Y., *July* 1, 1918.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending June 30, 1918.

1917	RECEIPTS.		
July 1.	To balance on hand		$2,592 88
	Maintenance and operation (last year)	$1,185 75	
	Inspection of Fert. Feed S. (last year)	20 47	
	Hatch & Adams funds	3,000 00	
	Maintenance and operation	28,846 39	
	Research, general	53,539 04	
	Administration	13,079 18	
	Investigations	21,892 90	
	Inspection of Fert. Feed S.	15,025 20	
	Communication	293 36	
	Rent	1,900 00	
	Repairs	418 04	
	General plant service	476 07	
			139,676 40
	Received for produce sold		2,855 71
			$145,124 99

EXPENDITURES

Maintenance and operation (last year)	$3,067 75	
Inspection of Fert. Feed S. (last year)	200 57	
Hatch fund	1,452 19	
Adams fund	1,254 88	
Maintenance and operation	24,738 84	
Research, general	52,611 12	
Administration	13,069 16	
Investigations, labor	21,892 88	
Inspection of Fert. Feed S.	15,025 14	
Communication	293 36	
Rent	1,900 00	
Repairs	418 04	
General plant service	416 07	
		$136,400 00
Remitted treasurer State of New York, produce		2,855 71
Remitted treasurer balance appropriations		438 39
Balance on hand June 30, 1918		5,430 89
		$145,124 99
Balance Ring Memorial Fund		1,152 32

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been forwarded to the Comptroller of the State of New York.

(Signed) W. O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1918.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

Gentlemen.— In accordance with the usual custom, I am presenting herewith a report of the operations of this institution for the calendar year 1918. I am also calling to your attention certain conditions and needs pertaining to the institution which should receive your serious consideration.

The report is the smallest in volume of any that has been presented during recent years. The explanation of this fact is that members of the Station Staff have entered war service or have been called to other positions without it being possible to fill the vacancies in a satisfactory way, and, in general, the thought and energy of members of the Staff have been diverted from a vigorous and continuous application to investigational problems by the stress and strain of the war. The great conflict has created an atmosphere of anxiety and uncertainty which has had its effect upon every phase of human activity in this country, and educational and research institutions have not been exempt from this influence.

ADMINISTRATION.

STATION STAFF.

There have been changes in the Station Staff of the usual character, due to the attractions offered by other institutions and commercial opportunities, in addition to which several of the Staff have entered into war service. Men of scientific attainments have had a peculiar and important relation to the winning of the war thru various openings of activity that have related to food, engineering and munitions.

In the spring of 1918, Rudolph J. Anderson, Associate Chemist, offered his services to the government. His offer was accepted and

*Reprint of Bulletin No. 457, December, 1918.

he was commissioned captain and attached to the surgeon-general's office. His work at first was the inspection of the food supplies at several cantonments. Later he was assigned to a school of nutrition at Camp Greenleaf, Chickamauga, Ga., for instruction to prospective inspectors of food.

George H. Howe, Assistant Horticulturist, enlisted for war service in the early part of the year, and was assigned to the medical corps. Subsequently, however, he was attached to the Walter Reed Hospital, Tacoma Park, D. C., for the purpose of aiding in preparing disabled soldiers for agricultural work, particularly along horticultural lines.

Members of the labor force of the institution have at various times been called to war service.

The Director of the Station served as Chairman of the Federal Milk Commission for the Middle States, with headquarters in New York City, from November, 1917, until July, 1918. This commission had brought before it very complicated problems relative to the cost of production and distribution of milk — some of them almost impossible of solution within the time and facilities available to the commission. Nevertheless, the commission established prices to the producer and to the consumer which prevailed during the first six months of 1918, and which in the main were said to be fairly satisfactory to the parties in question.

Certain changes in the Staff have occurred, due to absences for war service and to the attractions of other institutions. Further changes are threatened for the same reasons.

Godfrey L. A. Ruehle, Assistant Bacteriologist, accepted a position in the Michigan Agricultural College at a salary considerably in advance of that which he was receiving at this institution. This call was undoubtedly due to the good work which Mr. Ruehle had accomplished in dairy investigations. It was unfortunate that he could not have been retained, but the present budget system of the State rendered this impossible.

Everett P. Reed, Assistant Agronomist, has accepted the position of farm bureau agent in one of the counties of Ohio, at a salary greatly in advance of that which was assigned to him at this institution. It should be remarked in this connection that the demand for farm bureau agents and the salaries which are being offered in these positions are causing a serious problem in retaining men on the

teaching and investigating staffs of our institutions. It was not possible to retain Mr. Reed in competition with the inducements offered in Ohio.

James D. Harlan, B.S., a graduate of Pennsylvania State College, was appointed as Assistant Agronomist to fill the position vacated by Mr. Reed. Mr. Harlan has the advantage of a good knowledge of practical agriculture, which together with his scientific training should render his services useful to the institution.

Edward H. Francis, M. A., a graduate of Cambridge University, England, was selected to fill the place vacated by George H. Howe. Mr. Francis is a member of the London Zoological Society, and brings to the service of the State a training that has specially fitted him for observational work along horticultural lines.

John C. Baker, while still a member of the Staff, is soon to enter upon a commercial position in New York City. The salary which Doctor Baker will receive is two and one-half times that which he was receiving at this institution. He would have remained at a considerably less salary than that which he will receive in his new position, but, as stated in a former case, the present budget system of the State renders it out of the question generally to retain men at a moderate increase of salary, even tho this may be the wisest policy.

MAINTENANCE FUND.

During the fiscal year beginning July 1, 1917, the expenditures of the Station were as follows:

Personal service	$102,598 30
Maintenance and operation	30,575 45
Repairs	1,500 00
Drainage	427 50
Total	$135,101 25

The following are the appropriations available for the use of the Station during the fiscal year beginning July 1, 1918. This amount is $6,270 less than the request presented by the Board of Control:

Personal service	
Salaries and wages	$111,530 00
Maintenance and operation	
Fuel, light, power and water	6,000 00
Printing	15,400 00
Equipment	5,275 00
Supplies	9,000 00
Hired horses and vehicles	2,500 00

Maintenance and operation (*continued*)	
Traveling expenses	$4,000 00
Communication	2,000 00
General plant service	2,200 00
Rent	1,000 00
Repairs	2,500 00
Construction and permanent betterments	70,000 00
Printing (special)	10,000 00
Rent (special)	1,900 00
Total	$243,305 00

In accordance with the action of your Board, the following budget for the fiscal year beginning July 1, 1919, as amended by subsequent action, has been presented:

Personal service	
Salaries and wages	$115,160 00
Maintenance and operation	
Fuel, light, power and water	6,000 00
Printing	15,400 00
Equipment	5,275 00
Supplies	8,500 00
Hired horses and vehicles	3,000 00
Traveling expenses	4,000 00
Communication	2,500 00
General plant service	750 00
Rent	1,000 00
Repairs	3,000 00
Construction and permanent betterments	2,900 00
Total	$167,485 00

THE EXISTING BUDGET SYSTEM.

When the New York Agricultural Experiment Station was established by legislative action in 1881, an agency was created thru which the purposes of the institution should be accomplished, namely, a Board of Control. It has been the duty of this Board of Control to appoint a Director and a scientific staff in whose hands have been placed the immediate administration of the affairs of the institution. For thirty-two years this Board and this appointed staff were given complete autonomy in the expenditure of the funds provided for the use of the Station, limited only by the general regulations pertaining to the expenditure of State funds. In 1914 there was established a closely segregated budget system in which the salaries of all the positions in the Station were specified, and various sums of money were individually designated to pay particular classes of expenses. It has been the duty of the administration of the Station nearly a year in advance to anticipate the

status of its scientific staff and the necessary expenditures along from ten to fourteen lines. Such an anticipation of expenditures in an institution the work of which varies from year to year, requiring an unlike distribution of expense, cannot be intelligently made.

After more than four years' experience, it can be safely said that this budget has proved an administrative burden, and has not accomplished, for the Station at least, any fiscal economies, but rather the reverse. It has placed serious limitations upon the autonomy of the administration. However worthy the motives which lie behind such fiscal regulations, it may be safely asserted that, so far as education and research are concerned, experience indicates that the system in vogue not only is not helpful but is a decided drag on efficiency.

Certain statements by the draft administrator of the State of Wisconsin and director of the Society for the Promotion of Training for Public Service are illuminating in this direction. Doctor Fitzpatrick, in a very able treatise entitled "Budget-Making in a Democracy," writes as follows: "The segregated, that is, the minutely itemized, budget was an expression of mechanical efficiency. The recent changes proposed, permitting larger administrative discretion, are in the direction of a genuine efficiency."

Doctor Fitzpatrick recognizes that the legislature and the executive should be adequately informed in regard to the needs of a particular institution, and that a budget *proposal* should express in much detail the directions in which funds are needed. He makes this comment, however: "While the budget proposals are presented in great detail, the legislative bill proposes action only upon certain totals. It is not proposed that the Legislature shackle the administration by making (into) law all the supporting detail of the budget. The formation of the budget proposals is therefore in certain lump sums and not in the minute detail of the 'segregated budget'. If there is no accounting control and no supervisory control, or officials are dishonest, or public funds are dissipated, there may be excuse for detailed legislative appropriation, but if administrators are to be given an opportunity to serve the public they must not be mere automatons, registering legislative edicts in all their minute detail."

It does not appear that this institution has been accused of wasting or misdirecting public funds, and it does appear that for thirty

years the institution made progress and accomplished results which were regarded as satisfactory by the agricultural people of the State with a budget either a single lump sum or segregated into not more than three or four divisions.

SALARY AND WAGE CONDITIONS.

The increased cost of living constitutes a hardship to persons holding salaried positions. The value of a dollar has been nearly cut in half during the past few years. Little or no increase in the salaries of State employees has been allowed. It is true that by chapter 556, Laws of 1918, a ten per ct. advance was granted on all positions where the compensation is less than $1,500 per year, with the provision that the addition of this ten per ct. shall not cause the salary to exceed $1,500. This small increase falls far short of measuring up to the increased cost of living, and either State employees were greatly overpaid five years ago or they are greatly underpaid now. Organized labor seems to have little difficulty in securing a reasonable advance in wages, but teachers, investigators and certain other State employees appear to have received very inadequate attention in this particular.

During the past summer artisans employed in the erection of a new building on the Station grounds were receiving considerably larger pay than certain members of the Station scientific staff, and greatly larger than useful employees acting as assistants to the scientific staff. This state of affairs will have but one result, namely, it will be impossible to hold valuable services against the attractions of commercial positions and of institutions in other States. If the State of New York expects that its College of Agriculture, its Experiment Stations, indeed all its facilities for agricultural education, are to maintain high standards, it must give practical recognition to the fact that the success of all these efforts depends upon the intellectual and professional quality of those engaged in these lines of work, and that the State must maintain the standard of the work it has established in the face of vigorous competition.

NEW POSITIONS.

The salary recommendations in the budget adopted by your Board look to the establishment of the position of Bio-chemist on a basis independent of other departments. There is scarcely any

field of investigation in which chemistry does not play an important part. This is especially true with reference to biological problems, whether pertaining to botany, bacteriology, dairying or animal nutrition. No institution similar to this one should be without a strong department of biological chemistry.

It is highly important, indeed necessary, that in the immediate future we begin the preparation of museum material for illustrating the work which the Station has accomplished in the past. In order that this may be accomplished to a satisfactory extent it will be necessary to employ expert assistance. In view of the fact that two salaries have been or will be dropped from our payroll, I am urging that provision be made for the employment of such an expert at a salary of $2,000.

THE NEW BUILDING.

It is gratifying to report that the new administration, library and demonstration building, provided by the Legislature of 1916, has been completed, and is now occupied. It is proper that the public should now be informed as to the facilities which the building offers.

In the first place, it contains the administrative offices of the institution. A brief occupancy indicates that this will be found very satisfactory. Certainly the members of the administrative staff will find greater convenience, pleasure and encouragement in the facilities now placed at their disposal than was the case in the old mansion house which has for many years been occupied, and which was no longer adequate to the needs of the administrative work.

It is particularly true that the mailing department, upon which such a burden of effort is ordinarily thrown, and which needs so much space for the handling and storage of bulletins, is now in a position for far greater efficiency than has been the case.

The library has been moved to its new quarters, and under arrangements which it is hoped to make in the future it will be possible to bring together the now scattered portions which it has been necessary to distribute among the various departments.

The auditorium, which has a seating capacity of practically 600 persons, may now be placed at the disposal of the people of the State along any line that will promote agricultural progress. It is hoped that the various organizations of the State will find it con-

venient to meet with us in order to become more fully acquainted with the facilities of the institution and with the results of past investigations along various lines.

It is expected that the museum, for which we have adequate space, but which is not yet equipped with cases, will become a place of instruction where there may be visualized the various practical results which have been worked out through over thirty years of investigation. Such a museum will be unique in the character of its exhibits.

PUBLICATIONS.

The Horticultural Division of the institution has in process of preparation an additional volume, to be known as " The Pears of New York ". This will be the sixth in the series of fruit books, and will probably be ready for distribution sometime during 1920.

The first Director of this Station, a distinguished scholar and botanist, Dr. E. Louis Sturtevant, left at the institution a very valuable collection of notes on edible food plants. As this collection involved an immense amount of labor and is most valuable, it was felt that it should be put in form for publication, with such additions and editing as would be found necessary. The Horticultural Division undertook this work, and the manuscript is now ready for the printer. In view of the important food problems which now face the world and which are likely to become more and more serious, it is certainly desirable that we have the fullest possible information as to the sources of human food. It is for this reason that the State is asked to publish this volume.

BUILDING NEEDS.

Attention has been called several times to our need for new plant houses and a new cold-storage house. Because of the demands of the war upon the finances of the State, your Board has not been insistent that immediate appropriations should be made for these purposes. This is a matter, however, which cannot be long delayed because the present buildings, thru age and decay, have reached a condition that will not permit our using them very much longer. The Legislature of 1920 should be asked at least to make adequate appropriations for these two buildings.

The distribution of Station publications for the year has been in accordance with the following figures:

POPULAR BULLETINS.

Residents of New York	37,548
Residents of other States	2,486
Newspapers	767
Experiment Stations and their staffs	2,395
Miscellaneous	100
Total	43,406

COMPLETE BULLETINS.

Experiment Stations and their staffs	2,395
Libraries, scientists, etc	400
Foreign list	396
Individuals	4,175
Miscellaneous	100
Total	7,466

RESULTS OF STATION WORK IN 1918.

The following is a general summary of the activities of the scientific staff, with certain proposals as to future work. It is clearly evident that the work of the Station has not been as fruitful in all particulars as has been the case in former years. This is probably the experience of all other institutions of the same class, and the reasons for this lie entirely with the diversion of thought and the entering of war service by members of the staff.

DIVISION OF AGRONOMY.

Statement of work in progress and projects proposed.— During the season of 1918 the following lines of investigation have been under way:

Field Work.

(1) Seven coöperative experiments at various locations in the State on the fertilization of fruit, including pears, apples, grapes and cherries. These require supervision of annual care of orchards and vineyards, including application of fertilizers, harvesting of fruit, recording yields and growth records, also selection of proper cover crops in the fall.

(2) Six series of fertilizer plats on Station farm, work including direct supervision of soil preparation and application of fertilizer mixtures, seeding and planting, cultural care, harvesting, etc. This

field work takes the whole time of one field man from early spring to freezing up in fall.

(3) *Lysimeter work.*— This consists of the work connected with a set of 20 lysimeters, including planting annual crops in a regular rotation, analysis of all seed and fertilizer added, crops harvested and drainage waters collected from all tanks. This work takes up practically the whole time of one analyst.

(4) *Outdoor cylinder work.*— Work connected with a set of 48 tile cylinders. These are used in an experiment to determine the relation of calcium and magnesium carbonates to the growth of high alkali requiring crops. The soil is a Volusia loam of high lime requirements, and is compared with our Station soil.

(5) *Laboratory work.*— Besides the analytical work connected with our field, lysimeter and cylinder work, a considerable number of miscellaneous samples of material, especially lime and limestone, are analyzed annually. Such work is strictly confined to samples having a direct relation to a group of farmers, such as, for instance, the samples sent in by Farm Bureau workers. Anything with commercial bearing is rejected.

Projects Proposed for Coming Year.

(1) Sulphur compost work in coöperation with New Jersey Station. This consists of six large composts made up in such manner as to attempt to show the effect of bacterial action in rendering the phosphorus of floats available. The work consists of composting, mixing every ten days, and monthly analytical work on the same. At the end of incubation period of six to seven months, vegetation experiments are made on said composts. This work has now been running about twenty days.

(2) Proposed coöperative experiment with Department of Bacteriology, consisting of chemical and bacteriological studies of ammonification and ammonia fixation in manure and phosphate composts on a laboratory scale. Such work will be started immediately.

(3) Plant physiological work on the optimum mineral requirement of definite plants in water culture.

This work is an outgrowth of the work of Dr. B. E. Livingston, Doctor Shive and others, and is under partial direction of the former. This work has not yet been started at this date.

(4) Plant physiological studies of crops of high mineral content. This problem is under consideration.

(5) Some small plat work on varietal studies and selection of certain field crops, especially dent corn, spring wheat, and alfalfa varieties.

COÖPERATIVE WORK CARRIED ON BY DEPARTMENT OF AGRONOMY, OUTSIDE THE STATION FARM.

Orchard Fertilizer Experiments.

Pears	Lawrence Howard	Kinderhook.
Grapes	George Hammond	Fredonia.
Apples	Vick & Dildine	Elm Grove.
Apples	Great Bear Springs Company	Fulton.
Apples	E. L. Chapman	Albion.
Cherries	P. O'Neil	Geneva.

Tobacco Rotation Experiment.

George Harris (government agent)	Baldwinsville.

BACTERIOLOGICAL AND DAIRY DIVISIONS.

The members of these divisions have given their chief attention to the study of milking machines, stable and milk sanitation, and to a study of soil micro-organisms.

Milking machine investigations.— The need for labor-saving farm machinery during the present national crisis has caused the Station to give special attention to studies of milking machines. A recent census shows that there are about 5,000 milking machines in use in the State; but there would be many times this number if they were a complete success. Observation has shown that there are still many dairymen who discard the machines after two or more years of use, and one of the most frequent reasons given is that the machines are difficult to keep in a clean and sanitary condition.

Because proper testing of the sanitary efficiency of machines requires facilities for bacteriological analyses and dairy equipment not ordinarily possessed by manufacturers, the Station has felt justified in making extensive tests of the sanitary efficiency of the B–L–K machines which have been operated in our stables since 1908, and in making similar observations upon this type and other types of machines in use on farms in the immediate neighborhood. The results of these observations have been published during the year as Bulletin No. 450. In general, very few dairymen were found to be getting as satisfactory sanitary results as the Station is getting.

By using extreme care and facilities not found even on the best of our dairy farms, it was found possible not only to identify all of the sources of bacteria in and about B-L-K machines, but also to bring them under perfect control for short periods of time. When methods were used which were entirely practical for farms producing high-grade milk, the control, while less perfect, was sufficient to prevent the addition of significant numbers of bacteria to the milk drawn thru the machines.

In view of the fact that milk drawn thru machines thus cared for is more perfectly protected from unsanitary influences than is hand-drawn milk, the Station plans to continue these studies not only with the machines now in use, but also (where necessary because of fundamental differences in construction) with other types of machines. The object of the work will be to devise more convenient and usable methods of cleaning machines under ordinary farm conditions. Those methods which we now regard as the most successful have been described in a revised edition of Circular No. 54.

The control of market milk supplies.— During the year the coöperative studies upon methods of securing good milk, which were started in 1915, have been continued with good results. The control exercised has been based upon a laboratory analysis of milk samples secured from individual 40-quart cans of milk as they were delivered at the two pasteurizing plants which supply the larger part of the milk sold in the city of Geneva. During the first 30 months the only influence brought to bear upon the dairymen to induce them to bring good quality milk was a premium, varying from 8 to 24 cents per hundred pounds, which was offered for milk of a specified grade. Where the milk delivered continually failed to meet this standard, visits were made to the farms and analyses made to find the exact cause of the trouble. These results were reported to the dairyman with an explanation of the cheapest and simplest way of correcting the trouble.

At the end of 30 months it was found that payment based on the quality of milk, while effective in many cases, did not secure the elimination of unsatisfactory milk quickly, and beginning with July, 1918, more vigorous means of securing improvement have been used. Since that date the city health authorities have, after reasonable notice, excluded unsatisfactory milk wherever the dairyman

failed to care for his milk as directed. The effectiveness of this procedure is now being observed.

In the course of this work from five to six thousand samples have been examined yearly, a much larger number than has been examined in any other milk control laboratory in the State outside of New York City. Due to the simplicity of the microscopic method of examining milk developed at this Station, all of the work has been done by a single analyst. It is gratifying to note that this method of milk examination is coming into general use, having been accepted as a standard method of analysis both by the Committee on Standard Methods of Milk Analysis and by the surgeon-general of the United States army.

The studies made on individual farms in connection with this work have continued to uphold the conclusions previously reached (see Bulletin No. 443), that the sources of the excessively high numbers of bacteria found in the milk delivered at the pasteurizing plants were relatively few in number. The most important of these were cans which were improperly steamed and left moist with the covers on, improperly cleaned milking machines, and streptococcic infections of udders (garget or mammitis). Cooling of milk delivered within four hours after milking has been found to be unnecessary in the production of a milk of a grade equivalent to Grade A pasteurized. Even where the milk was from 12 to 16 hours old, excessively high bacterial counts were few in number wherever the above-mentioned sources of bacteria were under control, even tho the milk was as warm as 60° F.

The microscopic study of bacteria and fungi in soil.— The results of the work on the microscopic examination of soil mentioned in the Director's Report for 1917 has been published as Technical Bulletin No. 64. This bulletin gives the details of the technic which reveals the bacteria in the soil. It shows that the number of bacteria in soil is probably five, ten or even twenty times as great as indicated by the culture plate method (the only method available in the past for counting bacteria in soil). It furnishes additional evidence in confirmation of one point brought out in Technical Bulletin No. 51, namely, that the large spore-forming bacteria which are abundant in culture plates made from soil, actually occur in normal soil only as spores. The microscopic method does not reveal the presence of fungus mycelium in any soil except

where there is an unusual amount of organic matter, such as the leaf mold of woodland soil. In general, the microscopic examination of the soil has brought out that, when an organism is concerned which produces spores or any other resting stage, the plate count may not be an index of activity, but only of ability to produce spores, and its significance cannot be determined unless the microscope is used to distinguish between spores and active vegetative cells.

The ammonification of manure in soil.—The soil flora studies carried on by this division in previous years have shown what kinds of bacteria are to be expected in soil, but have given little indication as to the practical significance of the various kinds present. It is planned to follow up this work by learning which kinds predominate in soil under conditions of practical importance to agriculture and to study the activities of such kinds of organisms. The first condition of this sort selected is the decomposition of manure in soil.

When manure is mixed with soil, the organisms that increase in number to the greatest extent belong to the group of non-spore-forming bacteria described in 1917 in Technical Bulletin No. 59. The majority of these forms are difficult to recognize, but two types were found which could be identified with previously described species, and these two types were selected for study. They both proved to be vigorous ammonifiers of manure in soil.

The proof of the agency of any particular organism in some chemical transformation in the soil (such as the ammonification of manure) is not as simple as has often been supposed. To show that the organism causes the transformation in pure culture under laboratory conditions does not prove that it is the agent in this transformation in soil under natural conditions. In regard to the two ammonifiers selected for this work, however, more complete proof has been obtained than has been offered in the past to demonstrate the agency of any other soil bacteria in this process. This thoro test has been made because the general impression in the past has been that spore-forming bacteria, instead of non-spore-formers, were the most important ammonifiers in soil. The steps taken to obtain this proof, together with detailed descriptions of the two organisms in question is shortly to be published as a technical bulletin.

Ammonification in the manure pile.— Work is now in progress to determine which microörganisms cause the ammonification that

takes place in the manure pile, and to find an organism causing especially vigorous ammonia production. This work is expected to lead up to a study of practical methods of fixing this ammonia in the manure, thus preventing the loss of considerable nitrogen.

Potato scab investigations.— Little progress has been made upon this investigation during the year, chiefly because war conditions have temporarily stopped the coöperative work. Work on the classification of the group of organisms concerned (Actinomycetes) is still being continued.

COÖPERATIVE STUDIES.

Methods of controlling the sanitary quality of milk	White Springs Farm Dairy Company. Geneva Milk Company. Geneva Board of Health, and about 50 dairymen in the vicinity of Geneva.
Stable and milk sanitation	Illinois Agricultural Experiment Station.
Potato scab investigations	Department of Botany, University of Illinois.

STATEMENT OF AMOUNT OF BABCOCK GLASSWARE TESTED FROM DECEMBER 1, 1917, TO DECEMBER 1, 1918.

10 per ct. bottles	16,734
8 per ct. bottles	18,032
30 per ct. 9-gram	84
30 per ct. 18-gram	586
40 per ct. 9-gram	12
40 per ct. 18-gram	394
50 per ct. 9-gram	1,863
50 per ct. 18-gram	1,162
50 per ct. 9-inch, 18-gram	242
50 per ct. 9-inch, 9-gram	349
17.6 c.c. pipettes	3,987
18 c.c. pipettes	122
9 c.c. pipettes	254
6 c.c. pipettes	66
8.8 c.c. pipettes	24
Skim-milk bottles	236
Acid measures	589
Total	44,736
Total rejections	297
Number packages sent out	1,004

BOTANICAL DIVISION.

Seed testing.— Bulletin No. 446, published in January, 1918, reports the results of seed tests made by the Station during 1916 and 1917. It gives the percentage of pure seed, foreign seed and

inert matter in each of 906 official samples of seed collected by agents of the Commissioner of Agriculture; also a summary showing the condition, as regards purity, of 1251 unofficial samples sent in by farmers and seed dealers.

Among the 906 samples analyzed, there were 51 which were violations of the New York seed law. Altho containing more than 3 per ct. of foreign seed, they were not so labeled when offered for sale.

The analyses of the unofficial samples indicate that there is much poor and impure seed on the market. Plainly, there is need of a stricter law governing the sale of agricultural seeds. All lots of seed containing 10 pounds or more, and sold for seeding purposes within the State, should be labeled in such manner as to show the purity and viability of the seed.

The velvet-stemmed collybia — a wild winter mushroom.— This is the title of Bulletin No. 448, which contains an account of an edible fungus remarkable for its ability to withstand cold weather.

The velvet-stemmed collybia, *Collybia velutipes*, is a common wild mushroom which should be better known and more generally used for food. It has a reddish yellow cap, white gills and velvety brown stem. It grows in dense clusters on stumps, logs and partially buried wood of many kinds. Its principal season is October, November and May, but it may be found also in spells of mild weather during winter. The caps may freeze and thaw several times without injury.

In flavor and consistency it is excellent. Its most objectionable feature is the viscidity of the caps, which makes them disagreeable to handle and difficult to clean. The caps possess a remarkable capacity for the absorption of water. In the presence of moisture shriveled caps revive. Owing to its season of growth there is little danger of confusing the velvet-stemmed collybia with poisonous species and it is not often seriously infested with worms.

Preparation for cooking consists in the removal of the stems, picking off adhering leaves and blades of grass and washing. Peeling of the caps is unnecessary. A good way to cook the fungus is to boil it for thirty minutes, then fry for fifteen minutes in butter, oleomargarin or bacon fat, and season with salt and pepper.

Any surplus which it is desired to preserve for future use may be dried.

FIELD EXPERIMENTAL WORK OF BOTANICAL DIVISION, 1918.

Potato experiment .... L. L. Foote, Malone.
W. S. White, Cadyville.
F. A. Sirrine, Riverhead.

DIVISION OF CHEMISTRY.

BULLETINS PREPARED IN 1918 BY CHEMICAL DEPARTMENT.

1. Analyses of 550 Samples of Commercial Fertilizers.
2. Analyses of 971 Samples of Feeding-Stuffs.
3. Analyses of 120 Samples of Insecticides.
4. Studies of Milk.
   I. The Preparation of Pure Casein.
   II. Method for Making Electrometric Titrations of Milk and Other Solutions Containing Proteins.
   III. Free Lactic Acid in Sour Milk.

The methods which have been used for the preparation of casein from cow's milk produce an impure product, containing calcium caseinate, calcium phosphate, and often products formed from the hydrolysis of casein. Casein is a basic substance in the cheese industry and it is important to know its properties, which can be learned satisfactorily only from a study of the pure substance. The New method of preparing pure casein depends upon careful control of the introduction of acid into the body of the milk used, and simultaneous stirring of the milk by a mechanical stirrer revolving at a high speed. By this method not only can a pure product be made, but the time required is much shorter than by other methods and the yield of casein is larger.

In studying the chemical properties of casein it is desirable to add known amounts of acid to the milk or casein under study, and after each addition to determine the hydrogen ion concentration, instead of confining the work to titration with some indicator. The method devised accomplishes the desired results satisfactorily.

It has been the universal custom to speak of the acid constituents in sour milk as free lactic acid. Lactic acid in sour milk is present largely in combination as calcium lactate, but there is also some free lactic acid. Under ordinary conditions free lactic acid does not appear in appreciable amounts in souring milk for about 20 hours after inoculation with lactic acid organisms; the amount then increases more rapidly and in 48 hours is about 20 c.c. of tenth normal acid in 100 c.c. of milk. The rapidity of action and amount of free lactic acid present depend upon different conditions and especially the kind of organism present. The casein of milk begins to coagulate when the PH value reaches 4.64 to 4.78.

CHEMISTRY.

Status of Work.

Work has been practically completed during the past year in the following investigations:

1. A method for determining the condition of milk in relation of (*a*) abnormal water content; (*b*) pasteurization or heat; (*c*) presence of garget; (*d*) keeping quality. Practical applications in milk inspection.

2. Amount of carbon dioxide and carbonates in milk, and relation to abnormal milk.

3. Some properties of casein.

DIVISION OF ENTOMOLOGY.

Leaf-hoppers injurious to apple trees.— The investigation of the leaf-hoppers attacking apple trees was undertaken because early observations showed that more than one species was involved in serious outbreaks during recent years in apple orchards. It was believed that failure to recognize the different forms had probably led to errors in observations of the habits and life histories, and perhaps in recommendations relative to control measures. Detailed knowledge of the different forms was therefore of prime importance before conclusions could be drawn as to satisfactory repressive measures aiming either at the individual or collective control of the leaf-hoppers. The results of this study, as presented in Bulletin 451, show that apple trees are subject to attack by three species: *Empoasca mali* Le Baron, *Empoasca unicolor* Gillette, and *Empoa rosæ* Linnaeus. These display great similarities in certain activities and in the resemblance of nymphal and adult stages. As pointed out, differences exist in their habits, life histories and structures by which the various species may be accurately and readily identified. Contrary to certain recorded observations, *E. mali* hibernated largely, if not exclusively, in the adult stage. Two generations were observed. The species *E. unicolor* spent the winter in the egg stage and was single brooded, while *E. rosæ* overwintered in the egg stage, largely on roses, altho a few eggs were placed on apples. This latter species had two generations.

The leaf-hoppers differ considerably in feeding habits. The species *E. mali* obtains its food almost exclusively on tender terminal growth, causing a characteristic curling of the foliage. Both *E. rosæ*

and *E. unicolor* feed largely on older leaves, and they may be found on young and old apples trees. The former is more abundant on older trees, while the latter is more numerous on younger trees. Leaves attacked by the two species display white stippling of the upper surfaces.

In experiments with the leaf-hoppers as carriers of fire blight (*Bacillus amylovorus* Burrill) positive results were obtained with *E. mali*. No infections were noted in similar efforts with associated species, and the role of these as potential carriers of the disease was not clearly indicated.

The leaf-hoppers have a number of natural enemies, as various small spiders and hymenopterous parasites. A common and destructive enemy of *E. rosæ* is the egg parasite *Anagrus armatus* Ashmead. For protection from leaf-hoppers, chief reliance should be placed on spraying with soap and nicotine mixtures to combat the younger nymphs. A supplementary measure is destruction of weeds which harbor the insects. Attention is also called to the fact that *E. rosæ* breeds abundantly on currants and gooseberries, which should be considered in any plans that provide for the interplanting of apples with these bush fruits.

The grape root-worm.—The serious losses caused by the excessive numbers of the grape root-worm (*Fidia viticida*) in vineyards of western New York, and the many unsuccessful efforts of grape growers to control this pest led to a series of field tests during six seasons (1910 to 1915 inclusive) to learn the causes of these failures, and to evolve more practical methods of control. The results of these efforts are presented in Bulletin No. 453.

Having found during the first season's experiments that the beetles are susceptible to poison baits, the investigation developed along two lines: (1) To determine the effect of bordeaux mixture and poison upon the beetles; and (2) to learn the best method of using molasses and arsenate of lead in the spraying scheme. Two applications of bordeaux mixture and arsenate of lead applied at an interval of about 10 days were found to control efficiently the grape root-worm, and it was also noted that the effects of applications during successive seasons are cumulative. In seasons when the beetles were numerous the reduction in the number of beetles was generally not as marked with this system of treatment as with an application of molasses and arsenate of lead followed with a supple-

mentary spraying within a week with bordeaux mixture and arsenate of lead. The important sources of failure with both systems are lack of thoroness and improperly timed applications, either the first spray being applied too late or the interval between sprayings being too long. An additional cause of failure when the sweetened poison is applied is the lack of adhesiveness which results when molasses is added to arsenate of lead. If rains occur shortly after the spraying, there is danger that much of the material may be washed from the leaves. Laboratory tests indicate that this loss of adhesive properties is due to the cane sugar in the molasses. While studies are now under way to overcome this defect, field tests have proved that, if the vineyardist studies the weather and applies the sweetened poison at a time when rain does not occur in less than three days after the spraying, a large number of beetles will be killed. An application of bordeaux mixture and arsenate of lead within a week, or at most 10 days, after the molasses spray is advised in order to protect the vines from invading beetles, as well as to prevent losses from powdery mildew. Two gallons of molasses in each 100 gallons of spray material was found to give somewhat better results than one gallon, and a cheap stock molasses proved more effective than the refined grades.

Altho nicotine sulphate can be used in bordeaux mixture and arsenate of lead with safety on foliage of Concord grapes, a combined spray for the grape root-worm and the grape leaf-hopper (*Typhlocyba comes*) was not found to be feasible, at least during the seasons when the tests were made, since the periods when control measures are effective for the two insects do not coincide.

Incidentally it is to be noted that the number of grape root-worms fluctuated considerably during the several seasons that the investigation was in progress, and this was found to be related to the prevalence of certain ground beetles which are predaceous enemies of this pest.

Insect injuries of apple fruit.— The enforcement of the New York State Apple Grading Law had clearly shown the necessity on the part of orchardists of a more careful discrimination of fruits with respect to their imperfections. Attempts to grade fruits more closely have led to an unusual demand upon the Station for information as regards the nature of the agents that are responsible for the disfigurement of apples. The purpose of Circular No. 57 is to help

the fruit-grower to distinguish the different kinds of insect injuries that appear on the fruits at picking time. In many cases the work of the insect is quite characteristic and often more conspicuous than the pest itself. When the grower has once learned to recognize these defects, he can easily tell which insects are least under control in his orchard, and can modify his spraying practices accordingly. Only those insects are considered which attack the fruits, and the extent of this injury is not always a measure of the damage caused by a particular species. Many serious pests do not work on the fruits at all. There are some insects which destroy more fruits than are apparent from the results at picking time. For example, bud-moth larvæ and leaf-rollers cause many of the young fruits to drop, so that evidence of the injury is not present later in the season. The circular contains illustrations of the injurious work of fourteen of the more important insects that attack apples, and a chart which shows clearly the periods in the development of the fruits when damages occur. There is also included a spraying schedule which outlines the principal treatments for the protection of apple trees.

COÖPERATIVE EXPERIMENTS, DIVISION OF ENTOMOLOGY.

Nature of activity.	Coöperator.	Location.
Control of sinuate pear-borer	Dewitt C. Haight	Croton Falls.
Control of pear thrips	A. W. Hover	Germantown.
Control of pear thrips	Wessel Ten Broeck	Hudson.
Control of pear thrips	F. B. Harrington	Hudson.
Control of pear thrips	Fred and William Hallenbeck	Hudson.
Control of pear psylla	Oswego County Farm Bureau, E. Victor Underwood, Manager	Oswego.
Control of pear psylla	E. J. Lonis	Hannibal.
Control of pear psylla	Middlewood Farms	Varick.
Control of pear psylla	Fred Hammond	Geneva.
Control of pear psylla	McKay Brothers	Geneva.
Control of rosy aphis	E. S. Gifford	Gasport.
Control of rosy aphis	F. Dietrick	Wilson.
Control of rosy aphis	Isaac Palmer	Olcott.
Control of rosy aphis	S. F. Burton	Ransomville.
Control of rosy aphis	F. D. Weaver	Lockport.
Control of rosy aphis	H. J. Silsby	Middleport.
Control of rosy aphis	H. H. Freeman	Kent.
Control of rosy aphis	John Beckwith	Lyndonville.
Control of rosy aphis	G. E. Snyder	Albion.
Control of rosy aphis	Lynn Burrows	Albion.
Control of rosy aphis	C. M. Harding	Knowlesville.
Control of rosy aphis	Mrs. Ida Lafler	Albion.
Control of rosy aphis	H. E. Wellman	Kendall.
Control of rosy aphis	John Beckwith	Demster.
Control of rosy aphis	Maxwell Brothers	Geneva.
Control of green apple aphis	Orleans County Farm Bureau, L. C. Steele, Manager	Albion.

Nature of activity.	Coöperator.	Location.
Control of green apple aphis..	Donahue, McCrellis, Mack Company	Holley.
Control of green apple aphis..	Thomas Mack....................	Holley.
Control of green apple aphis..	B. G. Wilson......................	Waterport.
Control of green apple aphis..	Mrs. George Rollfe................	Lyndonville.
Control of green apple aphis..	Dayton True.....................	Holley.
Control of green apple aphis..	D. A. Salisbury..................	Holley.
Control of green apple aphis..	John Beckwith.....................	Lyndonville.
Control of green apple aphis..	E. M. Mower.....................	Carlton.
Control of green apple aphis..	Ora Lee..........................	Albion.
Control of green apple aphis..	Clarence T. Powley................	Lyndonville.
Control of green apple aphis..	Ralph Wilson.....................	Holley.
Control of green apple aphis..	J. T. Peck........................	Albion.
Control of green apple aphis..	C. M. Harding....................	Knowlesville.
Control of green apple aphis..	E. C. Paine.......................	Albion.
Control of green apple aphis..	Leslie Tanner.....................	Medina.
Control of green apple aphis..	William Thiel.....................	Lyndonville.
Control of green apple aphis..	A. A. Comstock..................	Kent.
Control of green apple aphis..	Clark Allis........................	Medina.
Control of green apple aphis..	H. H. Freeman.....................	Kent.
Control of cherry aphis.......	McKay Brothers..................	Geneva.

HORTICULTURAL DIVISION.

The Horticultural Division has published but one bulletin in 1918. This is No. 447, entitled "Newer Varieties of Strawberries." It contains full descriptions of 61 varieties, including discussions of such horticultural matters as yield, vigor of variety, health, sex of plants, season of bloom, ability to make plants, size of fruit, season of ripening, flavor and quality. A list of the most desirable of the 61 varieties is given.

The Department is preparing for publication data on fertilizers for apples in the orchard of Rome Beauties on the Station grounds. Eight years have elapsed since the first report on this experiment, and sufficient additional data have now accumulated to make a second report desirable.

A report is also being prepared on the work being done in the greenhouse with violets, to throw light on inheritance in asexual reproduction. This is the fifth season that this experiment has been under way, and data are now at hand sufficient to make a more or less valuable contribution to the subject under consideration.

The status of other work in the Department is given in a very general way in a few words. Experiments in breeding apples, pears, grapes, raspberries and other small fruits continue with indications of valuable results with all of these plants, both as a study of inheritance in the plants and as a means of producing new varieties, a number of which are now under test at the Station and elsewhere.

The Station has produced valuable new varieties of fruits in the past, and has been confronted with the problem of distributing these to the people of the State in an effective way. Recently a corporation has been formed for the purpose of accomplishing such distribution of our new varieties that are worthy of attention by growers. This is not to be a money-making organization, but thro it it is hoped to place within reach of the fruit-growers of the State such new varieties as secure commendation on the Station grounds and elsewhere.

FIELD EXPERIMENTAL WORK OF HORTICULTURAL DIVISION, 1918.

Vineyard experiments, Fredonia and Urbana.

POULTRY DIVISION.

So far as possible, chief attention has recently been given to working up and tabulating data collected in experiments to study the importance of certain mineral nutrients in the food for poultry. Some of the manuscript for report of this work is now being prepared.

Because of the greatly increased cost of standard foods, special attention has been given to a continuation of feeding experiments with poultry, that have been carried on before as opportunity permitted, relative to the importance of coarser vegetable food and to the utilization of waste foods.

Work on selective breeding experiments with poultry has been continued, involving during the year the testing of individual birds and the rearing of young from numerous matings.

In a study of soil requirements as to certain constituents, chiefly calcium and sulphur, experiments have been continued with soil plats which have been modified by annual applications of chemicals and growing crops to secure a gradual change without sudden disturbance of natural conditions. Buckwheat was the crop grown on these plats this year.

PUBLICATIONS ISSUED DURING 1918.

BULLETINS.

No. 446. January. Seed tests made at the Station during 1916–1917. Parts I and II. M. T. Munn. Pages 53.
No popular edition issued.

No. 447. February. Newer varieties of strawberries. O. M. Taylor. Pages 23, plates 9.
Popular edition, pages 10.

No. 448. February. The velvet-stemmed Collybia — a wild winter mushroom. F. C. Stewart. Pages 19, plates 11.
No popular edition issued.

No. 449. March. A non-parasitic malady of the vine. F. E. Gladwin. Pages 15, plates 3.
No popular edition issued.

No. 450. July. Control of bacteria in milking machines. Parts III and IV. Pages 68, plates 2.
Popular edition, pages 15.

No. 451. September. Leaf-hoppers injurious to apple trees. Pages 15, plates 4.
Popular edition. Pages 6.

No. 452. December. Commercial fertilizers. Pages 50.
No popular edition issued.

No. 453. December. Control of grape-root worm. Pages 75.
No popular edition issued.

No. 454. December. Analyses of insecticides and fungicides. Pages 15.
No popular edition issued.

No. 455. December. Feeding-stuffs. Pages 186.
No popular edition issued.

No. 456. December. Control of a city milk supply. Robert S. Breed. Pages 10.
No popular edition issued.

No. 457. December. Director's report for 1918. W. H. Jordan. Pages 25.
No popular edition issued.

TECHNICAL BULLETINS.

No. 64. January. Microscopic study of bacteria and fungi in soil. H. J. Conn. Pages 20.

No. 65. December. Studies relating to milk. Parts I and III, L. L. Van Slyke and J. C. Baker. Part II, J. C. Baker and L. L. Van Slyke. Pages 54.

CIRCULARS.

No. 54. Revised. Milking machines. Pages 5.

No. 56. January 1. Standardization of market milk. Dr. L. L. Van Slyke. Pages 9.

No. 57. February 20. Insect injuries of apple fruit. Bentley B. Fulton. Pages 15.

No. 58. (Condensed and reprinted from Technical Bulletin No. 49, pp. 31, 1916.) Counting bacteria by means of the microscope. Robert S. Breed and James D. Brew. Pages 12.

W. H. JORDAN

NEW YORK AGRICULTURAL EXPERIMENT STATION,
GENEVA, N. Y., January 15, 1919.

REPORT

OF THE

Department of Bacteriology.

R. S. Breed, *Bacteriologist.*

H. J. Conn, *Associate Bacteriologist.*

[1]G. L. A. Ruehle, *Assistant Bacteriologist.*

John W. Bright, *Assistant Bacteriologist.*

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[1]Resigned June 30, 1918.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY.*

MILKING MACHINES:

III. AS A SOURCE OF BACTERIA IN MILK.

IV. METHODS OF MAINTAINING IN A BACTERIA-FREE CONDITION.

G. L. A. RUEHLE, ROBERT S. BREED, AND GEO. A. SMITH.

SUMMARY.

1. In order to secure direct evidence as to the amount of bacterial contamination derived from milking machines, sterile water has been "milked" thru the machines under investigation from an artificial udder; and this rinse water has been analysed for its bacterial content. Thus all chance of outside contaminations from the body of the cow, the interior of the udder and other sources have been eliminated. The machine which has been studied the most intensively has been the Burrell-Lawrence-Kennedy, machines of this type having been in use at the Station since 1907. Some observations have been made upon Hinman and Empire milkers in use on dairy farms in the vicinity of Geneva.

2. Long continued observations have been made upon the bacterial quality of milk produced on dairy farms using each of these three types of machines.

3. The bacterial condition of the machines in use at the Station, and at some of the dairy farms, was found to be reasonably satisfactory and usually excellent. The condition of the machines on the majority of the dairy farms was found to be unsatisfactory; and in some cases very unsatisfactory, since in the latter case, in spite of the use of antiseptic solutions, the sterile water drawn thru the machines was found to contain millions of organisms per cubic centimeter.

4. The chief source of this heavy seeding with bacteria was found to be the teat-cups and rubber tubes; but the pails of the machines were also a prolific source of trouble in some cases.

5. The suction trap placed upon the recent types of B-L-K machines to prevent the return of contaminated condensation water from the vacuum piping into the pails was tested and found to be efficient for the purpose.

* Reprint of Bulletin No. 450, July, 1918.

6. The stable air which enters the machines during milking was analysed and found to add relatively insignificant numbers of bacteria to the milk, not being responsible for increasing the bacterial content more than 34 per c.c. under the worst conditions tested. The cotton filters for which provision is made on B-L-K machines were found to remove more than two-thirds of the bacteria from the air and also a small amount of dust. Since the total amount of contamination from the air was insignificant, the improvement due to the filters was so slight as to be undetectable in ordinary analyses of machine-drawn milk.

7. Dropping the teat-cups to the floor in dirty bedding was found to cause relatively large amounts of dirt to appear in the pails of the machines; but the bacteriological analyses of the sterile water, milked thru the machines at the same time, did not reveal the excessively high counts that might be expected. These filthy and intolerable conditions failed to give counts in excess of 25,000 per c.c. Here, as in other cases in our studies of the amount of bacterial contamination derived from dust, the germ count has been found to be an unsatisfactory index of the amount of dirt and filth present.

8. It has been found possible to completely sterilize milking machines by means of steam applied to the metal parts; and by thoro cleanliness, combined with harmless antiseptics, applied to the rubber parts of the machines. The precautions necessary are, however, impracticable even for certified dairy farms, and quite impossible to maintain on the average dairy farm.

9. Satisfactory bacterial results have been secured where practicable and suitable methods were used for keeping the machines cleaned, provided the teat-cups and tubes were immersed in any of the following antiseptic solutions: (1) Brines containing at least 10 per ct. of salt; (2) solutions of chloride of lime; (3) a combination of brine and chloride of lime; (4) lime water; (5) cold running water; (6) "montanin" (not recommended). Chloride of lime and running water were ineffective if the temperature of the solution was as great as 60° F.

10. The solution recommended for general use is chloride of lime dissolved in a saturated brine. Antiseptic solutions were not found to be successful unless the teat-cups and tubes were maintained in a cleanly condition.

INTRODUCTION.

Since 1906, this Station has milked part of the herd with milking machines and has had some phase of the milking machine problem under investigation. Some results of the experimental work have already been published in two bulletins (Nos. 317 and 353). The present bulletin includes two further reports on this subject, constituting Part III and Part IV in the series. Besides the data published in this series, some other data bearing on the question of milking machines have been included in Bulletins 380 and 443.

In these bulletins it has been reported that machine milking is practicable, a conclusion which is supported by the fact that since 1906 when milking machines were first tried at the Station, there has been a gradual increase in the number of herds in the State which are milked by machine until in a recent agricultural census, which was 96 per ct. complete, over 4600 milking machines were found to be in use. Nevertheless, those who are familiar with the use of machines under practical conditions realize that there is still a tendency for owners to discard them after using them from one to three years. It is to be expected that this tendency will become less marked as the defects in the machines are corrected, and the methods of using and caring for them are better understood.

The present report upon the machines has been drawn up in two parts: (a) A discussion of data gathered in an attempt to estimate the relative importance of milking machines as a source of bacteria in fresh milk, and (b) the results of tests made to determine the best methods of keeping the machines in a sufficiently germ-free condition to make them practicable for use in producing high-grade milk.

The first part of the report belongs in the general series of investigations begun at this Station in 1906 on the relative importance of the various sources of bacteria found in fresh milk.[1] A recent bulletin in the series from the Illinois Station discusses the amount

[1] Harding, H. A., Wilson, J. K., and Smith, G. A. The modern milk pail. N. Y. Agr. Exp. Sta., Bul. 326. 1910.
Harding, H. A., Ruehle, G. L., Wilson, J. K., and Smith, G. A. The effect of certain dairy operations upon the germ content of milk. N. Y. Agr. Exp. Sta., Bul. 365. 1913.
Harding, H. A., and Wilson, J. K. A study of the udder flora of cows. N. Y. Agr. Exp. Sta., Tech. Bul. 27. 1913.
Ruehle, G. L. A., and Kulp, W. L. Germ content of stable air and its effect upon the germ content of milk. N. Y. Agr. Exp. Sta., Bul. 409. 1915.

of bacterial contamination from common dairy utensils other than milking machines.[2] The present bulletin is intended to continue and supplement this study of dairy utensils as well as to give the best methods of caring for machines.

MILKING MACHINES: III. AS A SOURCE OF BACTERIA IN MILK.

PREVIOUS STUDIES.

A large number of papers discussing various aspects of the milking machine problem have already appeared. Some of these have dealt almost wholly with the effect of the machine on the amount of milk produced, or on the cost of operation of machines, and like problems. Others contain only general statements about the germ content of the machine-drawn milk, or about its keeping quality. Only those papers which give quantitative data on the germ content of machine-drawn milk are considered here.

Probably the first paper that discusses this problem is that of Harrison,[3] who in 1897 compared the germ content of hand-drawn and machine-drawn milk at the Experimental Farm at Guelph. In 235 analyses of machine-drawn milk the germ content as determined by a count of colonies on gelatin plates varied from 71,124 to 243,327 per c.c. with the greater number of the analyses showing counts between 100,000 and 200,000. In 94 analyses of hand-drawn milk from the same stable, the gelatin plate count varied between 645 and 63,422 per c.c., the numbers usually being between 1000 and 10,000. He concluded that milk drawn by the Thistle machine contained more bacteria than did hand-drawn milk.

In 1898, Backhaus and Cronheim[4] working at Königsberg, Prussia, reported a single analysis of milk drawn with a Thistle machine which showed a count of 1,187,000 colonies per c.c. They concluded that machine-drawn milk was low in sediment but high in germ content as compared with hand-drawn milk.

In 1902, Bordas and Raczkowski[5] in reporting bacteriological and acidity tests of milk from a dairy farm in France compared the milk as drawn by a mechanical milker with that drawn by hand. The number of colonies developed on lactose gelatin from milk drawn from the udder under aseptic precautions was 1700 per c.c. Milk drawn by hand and by machine when no aseptic precautions were used gave counts of 4,600 and 402,000 per c.c., respectively. When special precautions were taken, the hand-drawn milk had a count of 4,900 and the machine-drawn of 52,000 per c. c. The

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[2] Prucha, M. J., Weeter, H. M., and Chambers, W. H. Germ content of milk: II. As influenced by the utensils. Ill. Agr. Exp. Sta., Bul. 204. 1918.

[3] Harrison, F. C. Machine-drawn milk versus hand-drawn milk.—Some bacteriological considerations. Ontario Agr. Col. and Exp. Farm, Ann. Rept. 1897, p. 128–132. 1898. Also *Centralbl. f. Bakt.*, Abth. II, 5:183–189. 1899.

Harrison, F. C. The bacterial contamination of milk. *Rev. Gen. du Lait*, 2:457–463, 481–489, 510–519, 538–546. 1903.

[4] Backhaus and Cronheim, W. Ueber aseptische Milchgewinnung. *Ber. d. landw. Inst. Univ. Königsberg im Pr.*, 2:12–33. 1898.

[5] Bordas, F., and de Raczkowski. De la traite mécanique, dans l'industrie laitière. *Compt. rend. Acad. d. Sci. Paris*, 135:371–372. 1902.

acidity of the machine-drawn milk was noticeably higher after 24 and 36 hours than that of the hand-drawn milk. They conclude that machines could be kept in a satisfactory condition and that milk drawn by machine could not be contaminated with disease germs.

Later, Barthel[6] reporting as bacteriologist for the Aktiebolaget Separator in Sweden upon a new type of machine, in which the milk was drawn directly into the pail without passing thru rubber tubes, compared the germ content of milk drawn with a suction type of machine with that of hand-drawn milk. The two counts given for the machine-drawn milk are 19,540 and 88,400 per c.c., while those of the hand-drawn milk are 2520 and 1100 per c.c. When similar comparisons were made with the new type of machine, four tests of machine-drawn milk gave the following counts; 3400, 1000, 970, and 1070 per c.c. The hand-drawn milk showed counts of 20,170, 6080, 5500, and 3900 per c.c. He concluded that the new type of machine had a great advantage over the older suction type of machine because of the lower germ content of the milk drawn with it.

Erf[7] recorded two comparisons between the germ content of hand-drawn and machine-drawn milk, the latter being drawn with a Burrell-Lawrence-Kennedy machine. In the first comparison, the hand-drawn milk gave a count of 3700 per c.c., while the machine-drawn milk gave 2200 per c.c. In the second comparison the counts were 1520 and 800 per c.c., respectively. He does not state what method of cleaning was used to produce these results. Tests were also made of the effectiveness of antiseptics in keeping the rubber tubes sweet, those used being a saturated solution of boracic acid, a one per ct. solution of formaldehyde and a solution of lime. Comparisons were made of the keeping quality of the milk drawn into the machines after treatment with these antiseptics, and the formaldehyde was found to be the most effective in keeping the tubes sweet; but because of its poisonous nature was not regarded as practicable. The lime water was found to be useful and the most practicable of the three.

Stocking,[8] in 1905, studied the same type of machine at two dairy farms making comparisons between hand-drawn and machine-drawn milk. At the first farm, eight tests showed the machine-drawn milk to have an average germ content of 2,790,100 per c.c. (maximum, 9,417,600, minimum, 105,000) while the hand-drawn milk had an average germ content of 768,382 per c.c. (maximum, 4,179,200, minimum 33,233) counts being made on agar plates. At the second farm, in three similar comparisons, the germ content averaged 172,958 per c.c. for the machine-drawn milk and 9,400 for the hand-drawn milk. These tests were made before special methods were used for cleaning the tubes. Later, similar comparisons were made when various antiseptics or antiseptic measures were used. These included (1) laying the tubes in brine, (2) boiling in a borax solution, (3) steaming the tubes, (4) scalding the tubes just before use and (5) boiling for three-quarters of an hour in water. The method of placing the tubes in brine was found to be the best when all things were considered. Using this method at one farm it was found to be easy to produce machine-drawn milk with a lower germ content than that of the hand-drawn milk; but at the other farm this was more difficult because of the lower germ content of the hand-drawn milk.

Stocking and Mason[9] reported additional studies with the Burrell-Lawrence-Kennedy machine at the Storrs Experiment Station dairy. Comparisons were made of the germ content of machine-drawn and hand-drawn milk of two sets of cows which were frequently alternated. In ten comparisons when no special methods

[6] Barthel, Chr. La traite méchanique au point de vue bactériologique. IIe. Cong. Internat. de Laiterie à Paris, Repts. Prélim., Sect. II, Sous-Sect. 7A, 3e Question, pp. 4. 1905.

[7] Erf, Oscar. Milking machines. Kan. Agr. Exp. Sta., Bul. 140. 1906.

[8] Stocking, W. A., Jr. Bacteriological studies of a milking machine. U. S. Dept. Agr., Bur. An. Ind., Bul. 92, Pt. 2, p. 33-55. 1907.

[9] Stocking, W. A., Jr., and Mason, C. J. Milking machines. Pt. 1. Effect upon quality of milk. Storrs Agr. Exp. Sta., Bul. 47, p. 105-129. 1907.

of sterilizing the tubes were used, the results averaged 15,524 per c.c. (maximum 35,300, minimum, 1660) in machine-drawn milk and 3144 per c. c. (maximum, 8890, minimum, 200) in hand-drawn milk. Tests were also made of the efficiency of the following as methods of keeping the tubes free from germs: (1) streaming steam, (2) lime water, (3) solution of borax (1 to 15), (4) 2½ and 3½ per ct. formalin, (5) 10 per ct. brine, and (6) "gold dust" solution (1 to 300). With the exception of the tests with the formalin, the results secured were not as good as those obtained at the same time with hand milking. In the course of this investigation air-relief filters were added to the machines, in which cotton was used as a means of filtering bacteria out of the air which entered the machine during the milking process. The original purpose of the first filters, which were suggested by Mr. Loomis Burrell, was to prevent contamination of the milk thru moisture entering the vacuum pipes and its return when the vacuum was broken at the end of milking. The work of Stocking and Mason with the air-relief filters led them to believe that the cotton was a very effective agent in reducing the bacterial contamination of the milk.

Hastings and Hoffman [10] compared the germ content of hand-drawn and machine-drawn milk, using separate sets of cows for each. The hand-milking was done in 12-inch open pails, and the rubber parts of the machines were kept in lime water between milkings. The analyses of 150 samples of machine-drawn and of 136 samples of hand-drawn milk gave results which slightly favored machine milking. Twenty-two per ct. of the machine-drawn samples gave agar plate counts under 1000 per c.c., 55.3 per ct. were between 1000 and 5000, while 22.7 per ct. were over 5000 (maximum count, 174,000). Of the hand-drawn samples, 19.8 per ct. gave counts less than 1000 per c.c., 44.1 per ct. gave counts between 1000 and 5000, while 36.1 per ct. gave counts higher than 5000 (maximum count, 892,000).

Edwards [11] studied the Burrell-Lawrence-Kennedy machine at Guelph comparing the germ content of machine-drawn and hand-drawn milk. In seven tests on machine-drawn milk, the counts varied between 203,000 and 1,208,000 per c.c. while the germ content of six hand-drawn samples varied between 3200 and 68,900 per c.c. No special precautions other than ordinary methods of cleaning were used to keep the machines free from bacteria. In nine tests where the rubber parts were boiled once per week, the germ content of the machine-drawn milk was greatly reduced on the date of boiling; but quickly rose to high numbers again before the next treatment. In two tests when extreme precautions, such as boiling the tubes, steaming and thoro cleaning, were used the counts were reduced to 1407 and 1776 per c.c. The author concluded that where the tubes were cleaned and boiled every day under strict sanitary precautions the germ content of machine-drawn and hand-drawn milk was approximately the same, but that milk drawn with a B-L-K machine may contain many more bacteria than hand-drawn milk.

The germ content of machine-drawn and hand-drawn milk has also been compared by Miss Meek.[12] At the beginning of her tests, the rubber parts of the machines were rinsed successively in cold, tepid and hot water and then hung up until used. Later the pails were steamed and the rubber parts laid in brine between milkings. In several dozen samples of milk from individual cows drawn by machine, she found an average germ content of 47,870 per c.c. while an approximately equal number of hand-drawn samples taken at the same time averaged 21,115 per c.c. A similar number of composite samples taken from the mixed milk of four or five cows averaged 83,143 per c.c. for machine-drawn and 26,895 for hand-drawn milk. At the beginning the hand-drawn milk clearly contained fewer germs than the machine-drawn milk but as the work progressed the machine-drawn milk came to have a better quality.

[10] Hastings, E. G., and Hoffman, C. Bacterial content of machine-drawn and hand-drawn milk. Wis. Agr. Exp. Sta., 24th Ann. Rept. 1906–7, p. 214–223. 1907. Also Wis. Agr. Exp. Sta., Res. Bul. 3. 1909. Also *Centlbl. Bakt.*, Abth. II, 22:222–231. 1909.

[11] Edwards, S. F. Bacteria and the Burrell-Lawrence-Kennedy milking machine. Ontario Dept. Agr., Bul. 159, p. 20–24. 1907.

[12] Meek, Elizabeth B. Bacterial efficiency of the milking machine. Penn. Agr. Exp. Sta., Ann. Rept. 1907–8, p. 146–159. 1908.

Rinsings from the can of the machine, and from the cups and hose were examined bacteriologically but the method of taking these samples is not described in detail. The first of these samples, taken before special precautions were used in keeping the tubes clean, gave counts in the hundreds of thousands or millions per c.c. of rinse water. Later when the tubes were washed more carefully and laid in brine between milkings, these numbers were reduced to a few thousand and finally to less than 100 per c.c.

Haecker and Little [13] give three comparisons between the germ content of machine-drawn and hand-drawn milk taken in the early part of their work before any special precautions were used in cleaning the machines. These averaged 3310 per c.c. for the hand-drawn and 37,090 per c.c. for the machine-drawn milk. A few comparisons were made later when (1) the tubes were taken apart and scrubbed each day, (2) the tubes were placed in lime water, (3) the tubes, were boiled for twenty minutes each day before being placed in lime water, or (4) were boiled five minutes each day and placed in lime water. In general they report lime water ineffective unless accompanied by boiling and emphasize the necessity of the most painstaking cleaning of the machines if milk of low germ content is to be secured from them.

A report on 26 tests of machine-drawn milk is given by Brainerd,[14] part of these being made before special precautions were taken, and part after lime water was used for keeping the tubes germ-free. Three tests, made when lime water was not used, gave counts of 32,000, 35,000 and 1,250,000 per c.c. In 23 tests where lime water was used the counts varied from 34,000 to 100,000 per c.c., with an average of 60,000 per c.c. The author concludes that when lime water is used, the germ content of the machine-drawn milk compares favorably with that of hand-drawn milk.

Orr,[15] who made an investigation of the sanitary quality of milk for several counties in England, examined the milk from two dairy farms which were using milking machines of different types. In both, however, the milk was drawn thru rubber tubing. Two tests made on different occasions showed the milk from the first farm to have a germ content of 172,500 and 494,000 per c.c. Similar tests from the second farm showed counts of 1,392,000 and 986,000 per c.c. The last two counts were higher than any obtained from hand-drawn samples gathered in the course of a rather extensive survey of the contamination of a local milk supply. The author concludes that the machine was alone responsible for the high counts obtained. They were cleaned by drawing a strong soda water solution thru them, this being followed by tepid water.

Soon after this, the first report upon milking machines by Harding, Wilson and one of us (S) [16] was issued from this Station. This bulletin dealt primarily with the effect of the method of handling on the germ content of the milk, two types of machines having been studied, the Globe and the Burrell-Lawrence-Kennedy. When the Globe machine was carefully washed but no further precautions taken, the germ content of 20 samples of milk was found to average 692,542 per c.c. An equal number of hand-drawn samples had a germ content of 16,643 per c.c. The cows from which the samples were taken were milked alternately by hand and machine. The analyses of 33 samples of machine-drawn milk indicated that there was a slight reduction in the germ content of the milk in three successive milkings with the same machine. When the B-L-K machine was put into use, the effect of keeping the rubber tubes and teat-cups in a 10 per ct. brine was tested. Eleven samples taken when brine was used had an average germ content of 17,086, while a twelfth sample gave a count

[13] Haecker, A. L., and Little, E. M. Milking machines. Neb. Agr. Exp. Sta., Bul. 108. 1908.

[14] Brainerd, W. K. The production of clean and sanitary milk. Va. Agr. Exp. Sta., Bul. 185. 1909.

[15] Orr, Thomas. Report on an investigation as to the contamination of milk. pp. 113, 18 figs., Beverly, England. 1908.

[16] Harding, H. A., Wilson, J. K., and Smith, G. A. Milking machines: Effect of the method of handling on the germ content of the milk. N. Y. Agr. Exp. Sta., Bul. 317. 1909.

of 176,620 per c.c. Thirty-six samples when brine was not used gave an average count of 188,580 per c.c. (maximum, 708,000, minimum, 9,500 per c.c.). Seven other series of tests showed the effect of excluding all air bubbles from the tubes while in the brine and of the effect of filtering the air entering the machine. Four other series of tests were made of minor points, the whole of the analyses leading the authors to the conclusion that both the brine solution and the cotton air filters were important aids in securing milk with a low germ content. In the later types of B-L-K machines used, the germ content of the milk was almost always less than 10,000 per c.c. when the proper precautions were used. However, dropping the teat-cups on the floor during the milking process or any gross carelessness in handling the machine caused surprising rises in the germ content of the milk and occasionally very high counts were obtained where no definite cause could be found.

Gorini [17] has studied the germ content of machine-drawn milk on a dairy farm in northern Italy where the Lawrence-Kennedy-Gillies machine was in use and was able to get milk of a lower germ content from the machine milkers than from hand milking. In one case, the hand-drawn milk had a germ content of 12,600 while the machine-drawn milk had a count of 3400 per c.c. The machine-drawn milk had a markedly better keeping quality than did the hand-drawn milk. He did not use brine or other antiseptics in this case but he carefully cleaned the machines, which were new when the tests were made.

Hoffman-Bang [18] studied machines of the same type in a Danish dairy, both from the standpoint of the germ content of the milk and of the effect of the machine milking upon the milk flow. By thoroly scrubbing the tubes and immersing them in a hot salt solution, he obtained results varying between 2000 and 231,000 per c.c. with an average of 27,000. The milk from the same cows drawn on alternate days by hand showed a germ content between 3000 and 34,000 per c.c. with an average of 11,000. Other antiseptics and antiseptic measures tried with varying success were (1) lime water, (2) a 15 per ct. salt solution, (3) live steam and (4) boiling the tubes for 15 to 20 minutes. He concluded that even with a sterile machine large numbers of germs were washed from the outside of the teats and udders of the cows and advised washing the teats and udders with warm water before milking.

Williams, Golding and Mackintosh [19] made bacteriological studies of eleven different makes of machines in a competitive trial arranged by the Royal Agricultural Society in England in 1913; but no machines were allowed to enter the competition where antiseptics of any sort were used in keeping them clean. Three of the machines that entered the trials were of the pressure type in which no rubber tubing is used, and eight were of the suction type. The bacteriological counts obtained from the three pressure-type machines averaged 675, 4603 and 5161 per c.c., respectively, while the averages from the eight suction-type machines varied from 1579 to 41,419 per c.c. Ten samples were analysed in each case. A series of twelve hand-drawn samples averaged 2666 per c.c. while the average of eleven machine-drawn samples taken at the same time was 6727 per c.c. So far as known the only one of the eleven machines now being sold in New York State is the Omega, the machine which was regarded as the best one submitted in the trials.

Miss Wing [20] studied the Burrell-Lawrence-Kennedy machine. Seventy-one tests of machine-drawn milk from seven cows when the rubber parts of the machine were immersed in a 15 per ct. brine gave counts on agar plates which varied between 150

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[17] Gorini, C. Studi sulla mungitura meccanica, specialmente sotto il rispetto igienico batteriologico. Boll. Uffic. de Ministero di Agricultura, Indust. e Commer., Ann. 8 (1909), Vol. 2, Ser. C, No. 1, pp. 23–28. 1909. Abs. in *Milch Zeit.*, 39:183–185. 1910.

[18] Hoffman-Bang, N. O. Forsög med Molkemaskiner. Kgl. Veterinaerog Landbohöjskoles Labor. for Landökonomiske Forsög, 68de Beretning, p. 3–79. 1910.

[19] Report on the trials of milking machines, 1913. Royal Agr. Soc. England (London), pp. 23, 2 figs., 1914. Also paper presented at the Australia meeting British Assoc. Adv. Sci. 1914. Sect. M, Ref. 210.

[20] Wing, Lois W. Milking machines: Their sterilization and their efficiency in producing clean milk. Cornell Agr. Exp. Sta., Circ. 18. 1913.

and 12,300 colonies per c.c. Still lower counts were obtained in 21 tests when chloride of lime was added to the brine used in sterilizing the rubber parts, the individual tests varying between 150 and 3125 per c.c. A later test on six cows where 34 samples were analysed gave results varying between 350 and 4650 per c.c. (average 2342 per c.c.). A series of 24 comparisons between hand-drawn and machine-drawn milk in which the machine tubes were not cleaned after milking but placed immediately in the brine and chloride of lime solution gave average counts of 513 per c.c. for the hand-drawn and 3068 per c.c. for the machine-drawn milk. Other antiseptics tested to a limited extent but discarded for various reasons were (1) brine and hydrogen peroxide, (2) brine and alcohol, (3) brine and permanganate of potash, (4) brine and calcium peroxide, (5) copper sulphate, (6) vinegar, (7) acetic acid, (8) formaldehyde. She concluded that brine alone did not completely sterilize the tubes, but that chloride of lime and brine did practically do so.

Larsen, White and Fuller [21] compared the germ content of hand-drawn and machine-drawn milk, using the Hazelwood machine. In a series of 38 comparisons the average germ content of the hand-drawn milk was 10,739 per c.c., while that of the machine-drawn milk was 509,285 per c.c. No special methods of cleaning the machines were used. When the tubes were placed in brine between milkings the germ content of the machine-drawn milk averaged 252,166 per c.c. for 38 samples. When 2½ per ct. formalin was used the average was 72,058 per c.c. for 17 samples. When a saturated brine solution with 5 per ct. calcium chloride added was used, the average count was 134,070 per c.c. for 17 samples. The use of cotton filters reduced this to an average of 57,708 per c.c. for 12 samples. The investigators concluded that machine-drawn milk is higher in germ content than hand-drawn milk; but that soaking the tubes in brine and 5 per ct. calcium chloride and using air filters would greatly reduce the contamination from the machine. Later Larsen,[22] without giving additional data, states that lime water is the best germicide to use.

Hooper and Nutter [23] report tests with the Sharples milking machine, lime water being used as a solution in which to keep the milking tubes. In 21 tests made at the Kentucky Station dairy the average germ content was 3657 per c.c. In addition they give the results of the examination of the milk supplied from the dairy and sold in the City of Lexington. This milk, which was drawn largely by machine, was found to have during a one year period, an average germ content of 10,620 per c.c. when tested at the Experiment Station, or 8487 per c.c. when tested by the Board of Health of the City of Lexington. Results are also given for 178 samples taken from 57 cows milked by Sharples machines in a neighboring commercial dairy. The average germ content of these samples was 3389 per c.c.

A limited study was also made of the value of strong brine and a 5 per ct. soda solution as antiseptics in which to keep the rubber tubes; but both were discarded when it was found that the solutions themselves were not sterile. They concluded that with care milk with a low germ content could be produced on any dairy farm.

Güssow [24] made forty comparisons between hand-drawn and machine-drawn milk using a Sharples machine. No special precautions were taken in sterilizing the rubber parts of the machines. The average germ content for the hand-drawn milk was 4551 per c.c. while that for the machine-drawn milk was 70,646 per c.c.

Harrison, Savage and Sadler [25] report upon a few tests of milk as delivered in Montreal which came from farms where machines were in use. The average germ

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[21] Larsen, C., White, Wm., and Fuller, J. W. Preliminary report on the milking machine. So. Dak. Agr. Exp. Sta., Bul. 144. 1913.

[22] Larsen, C. Important factors affecting machine milking. So. Dak. Agr. Exp. Sta., Bul. 166. 1916.

[23] Hooper, J. J., and Nutter, J. W. Experiments with the Sharples mechanical milker. Kentucky Agr. Exp. Sta., Bul. 186. 1914.

[24] Güssow, H. T. Milk bacteriological investigations. Append. Rept. Minist. Agr., Exper. Farms Rept. for 1912-3, p. 478–480. Ottawa, 1914.

[25] Harrison, F. C., Savage, A., and Sadler, W. The milk supply of Montreal. 67 pp., 1914.

content for seven such samples was 778,428 per c.c. (maximum, 2,900,000, minimum, 100,000). A single comparison between hand-drawn and machine-drawn milk was given which was stated to be typical of many. The count of the machine-drawn milk as made from agar plates was 700,000 per c.c. while the hand-drawn milk had a count of 36,000 per c.c. They concluded that under practical farm conditions, machine-drawn milk had more bacteria in it than ordinary hand-drawn milk.

Moak,[26] who has charge of the inspection of the certified milk sent to Brooklyn, N. Y., reports upon the results obtained on ordinary and certified farms which use the Burrell-Lawrence-Kennedy machine. Chloride of lime and brine, or montanin (see page 174) were used as antiseptics for keeping the rubber tubes free from bacteria. At first the type of machine used was similar to the one used by Harding, Wilson and one of us (S) and also by Miss Wing. In this type of machine cotton filters are used at the place where the machines are connected with the vacuum piping system. Moak found that the filters did not stop the entrance of condensation water into the pail. An analysis of the water having shown that it contained large numbers of bacteria, a trap was devised by the manufacturers to prevent the entrance of this contaminated water into the milk. Four tests made on a dairy farm showed the following counts, where the older type of machine was used; 278,000, 275,000, and 288,000 and 214,000 per c.c. Under identical conditions where the new type of machine was used the counts were 4280 and 2960 per c.c. In 182 tests from a certified farm where the new type of machine was used, the counts averaged 2962 per c.c. for milk as delivered in Brooklyn. He also gives counts from machine-drawn milk of 11 individual cows which varied between 640 and 2520 per c.c. Another series of 16 counts from individual cows gave an average count of 880 per c.c., with two counts as low as 40 per c.c. After using a 2 per ct. montanin solution for 49 days, rinsings of the tubes with sterile water showed them to be free from bacteria. A series of 16 tests of the milk from two certified farms as delivered in the city showed an average germ content under these conditions of 5360 per c.c. He concludes that certified milk may be produced on farms where milking machines are used but does not urge their use for this purpose.

Burri and Hohl,[27] working at Liebefeld, Switzerland, have compared the germ content of hand-drawn milk with that of milk drawn with the Omega milker. When no special precautions were taken to render the machine free from bacteria, the germ content of the milk was ordinarily between 100,000 and 500,000 per c.c., the average of 54 milkings being 204,574 per c.c. When the same set of cows was milked by hand, the average of 48 tests showed 6377 per c.c. (maximum 34,000, minimum, 500). Tests of rinse water showed that the excess contamination came from the interior of the machine. When steam was used to sterilize all of the machine except the four rubber-lined teat-cups, the germ content of the milk was as low as from the hand-milked cows (about 6000 per c.c.). This was further reduced to about 1,000 per c.c. by careful washing of the udder and teats of the cows. Similar low counts were obtained when the machines were taken apart, cleaned in hot soda water, and dried.

Ruediger,[28] in examining the germ content of milk received on a city market, has found that the milk from six farms where machine milking was practiced usually gave counts on agar plates in excess of 1,000,000 per cc., only one count (and that 785,000) being less than this number. The milk received from 6 farms in the same district where hand milking was practiced gave counts varying from 52,500 to 1,795,000 per c.c. When the machines were scalded just before use, the germ counts

[26] Moak, Harris. Recent experiments with the milking machine in the production of certified milk. Proc. Cert. Milk Pro. Assoc. of America, 7th (1914) Ann. Conv., p. 28–38. 1915.

[27] Burri, R., and Hohl, Joh. Einfluss des Melkens mit der Melkmaschine "Omega" auf die bakteriologische Beschaffenheit der Milch. *Landw. Jahrb. d. Schweiz*, Jahrg. 30, p. 240–255. 1916.

[28] Ruediger, G. F. The milking machine a source of bacterial contamination of milk. *Jour. Inf. Dis.*, 19:652–654. 1916.

were found to vary between 2430 and 130,000 per c.c. He concluded that the proprietary product "Bacilli-Kil" and chloride of lime solutions are unsatisfactory for preventing bacterial growth in the tubes and that when the machines are not carefully cleaned, and scalded just before use they are liable to be badly contaminated.

From the foregoing review, it appears that there is practically unanimous agreement that the suction type of milking machines (the most successful type from the mechanical standpoint) must be cared for by special methods of cleaning if they are to be maintained in a sufficiently germ-free condition to yield milk containing as few germs as that obtained by careful hand milking. Under practical farm conditions where dairymen have used methods of cleaning the machines comparable to those used in cleaning simple dairy utensils such as pails, strainers and the like, investigators have found that the machine-drawn milk frequently has a germ content of millions per c.c. Similar, tho not as high counts, have been obtained in practically all cases even where steam was available for sterilizing the pails and metal parts of the machines. Even on high grade farms such as those of agricultural colleges and experiment stations, the counts from machine-drawn milk have in almost all cases been higher than those from hand-drawn milk from the same stables. Where bacteriological tests have been made and special methods of caring for the machines developed, several investigators report as good or better results from machine-drawn as from hand-drawn milk. Probably the most extensive results of this sort are those of Hastings and Hoffman,[29] Hooper and Nutter,[30] and Moak.[31]

The majority of the workers agree that it is the difficulty of preventing the growth of germs in the teat-cups and rubber tubes which is chiefly responsible for the high germ content of machine-drawn milk. A few have regarded the air that enters the suction type of machines at the end of the milking process when the vacuum is relieved as a significant source of contamination; and the same workers have also held that, in machines of the B-L-K type where air continuously enters the interior of the tubing and teat-cups, a significant number of germs enters with it. As indicated in the foregoing review, Stocking and Mason[32] were the first to test the

[29] See footnote 10.
[30] See footnote 23.
[31] See footnote 26.
[32] See footnote 9.

use of cotton filters as a means of reducing this contamination. At the same time they noted that condensation water in the vacuum pipes ran back into the milk pails when the vacuum was broken at the end of milking; but the improvement noted from using the cotton filters was ascribed to the effect of the cotton acting as a filter in removing germs from the air. These filters on the B-L-K machines were enlarged and improved in the course of the work done at this Station by Harding, Wilson and one of us (S)[33]; Larsen, White and Fuller[34] also report that cotton filters are effective in lowering the germ content of the milk drawn by the Hazelwood machine. Later Moak[35] has shown that the condensation water from the vacuum pipes is badly contaminated and the manufacturers of the machines have found that the cotton filter used at the connection with the vacuum pipes was not effective in preventing the return of this water into the milk. These studies resulted in the use of a trap for collecting the condensation water and the placing of a cotton filter at another place on the head of the machine thru which the air entered when the vacuum in the pail is relieved at the end of the milking process. The lessening of the germ content of the milk which followed the use of these devices led Moak to regard them as important aids in securing milk of low germ content.

Many workers have reported trouble caused by the accidental dropping of the teat-cups of the vacuum type of machine during milking. These, acting as suction cleaners, quickly draw noticeable quantities of dirt into the machines. Altho no direct evidence has been presented to show the relative importance of this source of contamination, those who have spoken of it have regarded it as important.

The authors of three reports have called attention to the possibility that bacteria are drawn into the teat-cups from the outer surfaces of the udder or are washed from the outer surfaces of the teats by the milk. Harrison[36] mentions this possibility but presents no data. Hoffman-Bang,[37] and Burri and Hohl[38] present some data and conclude that these are significant sources of bacteria.

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[33] See footnote 16.
[34] See footnote 21.
[35] See footnote 26.
[36] See footnote 3.
[37] See footnote 18.
[38] See footnote 27.

The metal parts of the machine such as the pail and cover may add large numbers of bacteria to the milk, in the same way that milk pails, cans and other metal dairy utensils add bacteria to the milk if they are not properly cleaned. This is not a problem peculiar to milking machines, but is identical with the general utensil problem which has been discussed by Prucha, Weeter and Chambers.[39]

PRESENT STUDIES.

EFFECT OF MILKING MACHINES ON THE GERM CONTENT OF THE MILK DRAWN.

Observations have been made upon the total amount of bacterial contamination found in machine-drawn milk both as drawn in the Station stable and under ordinary commercial dairy conditions. The relative importance of stable air, dropping the teat-cups on the floor, and the condensation water in the vacuum piping as sources of bacteria have also been studied in detail. Since the present studies concern only those contaminations derived from the machines themselves, no attempt has been made to measure the importance of the exterior of the teats and udder as sources of bacteria in machine-drawn milk.

In earlier studies, the majority of the investigators have used the amount of contamination of hand-drawn milk as a standard for comparison with machine-drawn milk. However, this is an unsatisfactory standard as the amount of contamination of hand-drawn milk is highly variable. A much better standard is a numerical one based partly upon the experience of practical farmers in the production of certified milk, and also partly upon such numerical measures of the amount of contamination of milk as have been secured in special investigations. Thus Harding and Wilson[40] have shown that normal healthy udders, free in large measure from streptococcic infections, give milk with an average germ content of approximately 500 per c.c., Reuhle and Kulp[41] have shown that the dust in the air is a still less important source of bacteria, rarely being responsible for increasing the germ content of the milk more than 10 to 100 per c.c. Prucha, Weeter and Chambers,[42] on

[39] See footnote 2.
[40] See footnote 1, third reference.
[41] See footnote 1, fourth reference.
[42] See footnote 2.

FIG. 1.—THE BURRELL-LAWRENCE-KENNEDY MILKER.

FIG. 2.— HINMAN MILKER WITH PUMP (AT LEFT).

FIG. 3.— HINMAN MILKER.
Milk entering pail.

the other hand, have shown that the amount of contamination of milk from ordinary utensils is highly variable and is dependent upon the methods used in cleaning and caring for them. With proper care of utensils and reasonably good dairy conditions the germ content of fresh milk from cows with uninfected udders ought not to exceed 10,000 per c.c.

Machines used.— The machines studied were the Burrell-Lawrence-Kennedy (Fig. 1), the Hinman (Figs. 2 and 3) and the Empire (Fig. 4). The B-L-K machine was used at the Station and on two commercial dairy farms. The Hinman and the Empire milkers were each used

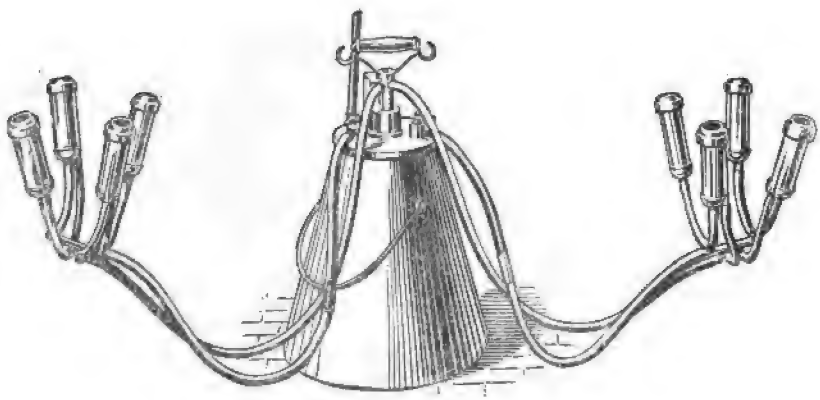

FIG. 4.— EMPIRE MILKER.

on four dairy farms. All of the dairy farms were located in the vicinity of Geneva and all of them supplied milk for the City of Geneva.

The Empire machine is one which uses both suction and air pressure on the teats, having double-lined teat-cups for this purpose. The other two machines use simple, conical, all-metal teat-cups with rubber mouthpieces. The main differences in principle between the Hinman machine and the other two machines lies in the fact that (a) the Hinman machine maintains no vacuum in the pail; but has a small vacuum chamber in the cover of the pail (Fig. 3); and (b) that the vacuum is secured by simple individual pumps (Fig. 2) for each milking unit. Both the B-L-K and the Empire machines maintain a 15-inch vacuum in the pail of the machine.

It should be stated that this selection of machines was a chance one; and in no way indicates our judgment as to the desirability of these three types.

Technique used.— In attempting to determine the relative importance of each of several possible sources of bacterial contamination of machine-drawn milk, it was necessary to devise some method by which each source could be studied separately. This was accomplished by using sterile water in an artificial udder (Fig. 5), and drawing it into the machine in a manner which simulates the true milking process very closely. Five liters of water have been used in each case and the time consumed in drawing this into the pail has usually varied between three and four minutes, a period of time which compares closely with that ordinarily consumed in drawing the principal part of the milk yield of an ordinary cow. .

FIG. 5.—ARTIFICIAL UDDER USED IN EXPERIMENTAL WORK.

In attempting to study the effect of each of several possible sources of bacteria about the machine itself, such as the dust in the air, the condensation water from the vacuum pipes, the rubber tubes and the like, it was necessary to develop still other methods of attacking the problem.

Thus in an attempt to determine whether the bacteria got into the milk (1) during its passage thru the teat-cups and rubber connecting hose, (2) from the head of the machine or, (3) from the pail of the machine, means were devised for collecting samples of water drawn from the "udder" at two points in its passage into the pail. The apparatus used is shown in Fig. 6. "A" was a device for collecting samples from the teat-cups and hose. It consisted of a 45 per c.c. sterile glass cylinder which was fitted with glass tubes so that a portion of the water which passed thru the connecting hose would be retained in the cylinder at the end of the milking process. In operation, however, it was found that this

cylinder was almost completely emptied at each pulsation so that the water retained was not representative of the entire "milking." "B" was a small sterile specimen jar of 200 per c.c. capacity which was hung by means of a bent wire from the partition of the pail so that it received a portion of the water as it sprayed into the pail at each pulsation. By examination of the way in which milk or water sprayed into a glass cylinder substituted for the regular pail, it was discovered that this resulted in securing a sample fairly representative of the whole milking. Samples from the pail itself gave results which indicated the total amount of contamination.

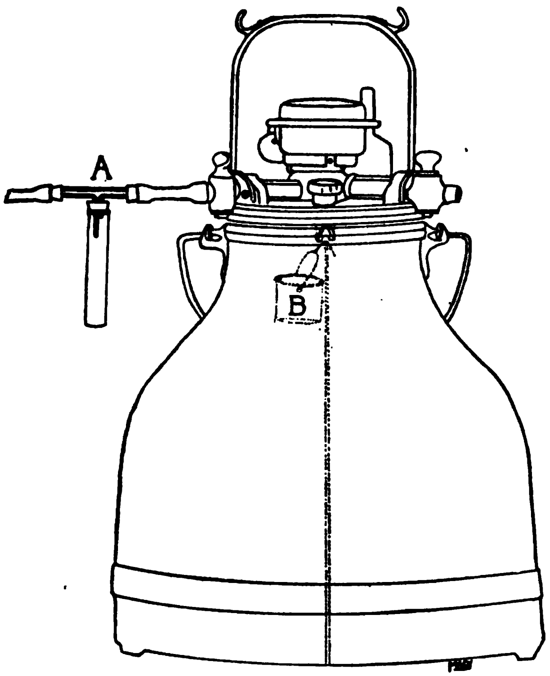

FIG. 6.—B-L-K MILKER SHOWING SAMPLING DEVICES.

Collection of samples, and methods of analysis used.—The samples were collected in sterile test tubes by means of sterile pipettes which were first used for agitating the water to be sampled. The plating of the samples was usually completed within an hour of the time of collection, or within three hours when collected at a distance from the Station. In the latter cases the samples were kept cold, when taken in summer, by immersion in water containing floating ice.

The medium used in plating had the following composition:

Agar, in shreds	15 grams.
Witte's peptone	10 grams.
Liebig's beef extract	5 grams.
Lactose, c. p	10 grams.
Distilled water	1,000 c.c.

The reaction of the medium was not adjusted, as the acidity varied between 0.9 and 1.2 per ct. normal acid to phenolphthalein. Experience at this laboratory has shown that a medium made of the above materials and of the above reaction to phenolphthalein has a hydrogen ion concentration between $P_H = 6.8$ and $P_H = 7.4$.

The colonies on the petri plates were counted under a hand lens (Engraver's lens no. 146) [43] after they were incubated for five days at 21° C and reincubated for two days more at 37° C. Whenever dilutions were made, the material was plated in triplicate in each dilution. Only such plates as showed more than 30 and less than 300 colonies per plate were used in computing the count per c.c. In a considerable portion of the work no dilutions were necessary. In these cases five plates were poured and all satisfactory plates counted.

It should be recognized (as is discussed in Bulletin No. 439) that all of the agar plate counts given in this bulletin, are counts of colonies which develop on petri plates. They are not counts of individual bacteria, but are rather counts of such single bacteria or groups of bacteria as grow into visible colonies under the conditions specified. While these counts may be compared with one another thus giving what is believed to be a fairly correct idea of the relative amount of contamination from each source, it should not be forgotten that the actual number of bacteria present was probably several times the figures given in each case.

PRELIMINARY SURVEY OF CONDITIONS AT THE STATION.

When this study of the amount and source of the bacterial contamination of milking machines was started (March, 1916), milking machines had been in use at the Station for ten years, and B-L-K machines for nine years. Soon after the original installation, the operation of the machines was placed in the hands of the regular dairy attendants under the supervision of one of us (S); but the attendants did all of the work of operating and caring for the machines.[44] The men chiefly involved in this work have not changed

[43] Sold by Bausch and Lomb Opt. Co.

[44] The two men, Mr. William Casey who has had charge of the cleaning and operation of the machines at the stable and Mr. William Lydon, who has had charge of the cleaning of the machines at the dairy, have done their work so efficiently that no small part of the credit for the successful operation of the machines during all of these years really belongs to them.

during the ten years and the work has been done as a regular routine. No regular bacteriological tests of the Station milk have been made during the time, but numerous analyses made at irregular intervals have invariably shown that the milk had a low germ content, that is, usually under 10,000 per c.c.

During this time the routine method of cleaning the machines has been as follows: Immediately after each milking, a large pailful of clean cold water was drawn into each of the machines thru the teat-cups. This was followed by a pailful of hot soda water, and finally by a pailful of clean hot water. After the evening milking, the pails of the machines were emptied, rinsed with cold water, and left until the following morning; but after each morning milking the pails and heads of the machines were sent to the dairy where they were more thoroly washed and steamed for a few minutes in a steam chest (with the exception of the pulsator piston). The pails then stood in a warm room with the heads on them until the evening milking, a procedure which was later found to be unsatisfactory because of the frequent presence of a small amount of moisture in the pail.

In all of the earlier work as discussed on pages 119–120, the teat-cups and rubber tubes were kept in a brine solution between milkings; but just before the more detailed experimental work reported in this bulletin was started the solution of brine was discarded in order to test the efficiency of chloride of lime. The strength of the solution used was carefully maintained and tested for available chlorine. This was maintained between 35 and 266 parts per million.[45]

On Tuesday of each week these tubes were sent to the dairy and scrubbed with spiral brushes and a warm soda solution, after which they were again placed in the chloride of lime solution.

In making tests to determine the amount of contamination of the milk which was derived from the machines themselves, five liters of sterile water were "milked" from the artificial udder as

[45] This solution was prepared by adding one quart of a strong stock solution to twenty-five gallons of water in a large earthenware jar. The stock solution was prepared by adding a 12 ounce can of dry bleaching powder to one gallon of water in a tall glass jar. This was allowed to stand for twenty-four hours before use, when the clear, greenish-colored solution could be decanted as needed. The solution in the large crock in which the tubes were kept was reinforced with one pint of fresh stock solution once per week, thus maintaining the amount of available chlorine in the solution. The tubes were suspended in the solution from hooks in the cover of the crock.

described (page 129). The results are given in Table I. The first two of the twenty-two tests were made on separate units, but in the later tests, two successive milkings, or later still four successive milkings were carried out with each unit. Test No. 5 was omitted in computing the averages as the difference between the two milkings was so much greater than that noted in the other cases that its inclusion in the averages would lead to erroneous conclusions.

TABLE I.— AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES.

Agar plate counts per c.c. of sterilized water, "milked" thru machines cared for in ordinary way.

TEST NUMBER.	Date.	First milking.	Second milking.	Third milking.	Fourth milking.
	1916.				
1	Mar. 1	*6 700	....	....	....
2	Mar. 1	*3 100	....	....	....
3	Mar. 2	1 320	3 890	....	....
4	Mar. 3	1 230	1 430	....	....
5	Mar. 7	*35 800	*22 200	....	....
6	Mar. 8	2 500	2 010	....	....
7	Mar. 9	10 800	10 720	....	....
8	Mar. 10	4 800	1 900	....	....
9	Mar. 11	680	380	....	....
10	May 11	3 200	2 400	....	....
11	May 12	113	171	....	....
12	May 13	460	320	....	....
13	May 20	710	870	970	335
14	May 23	2 500	4 200	2 720	2 250
15	May 24	1 110	950	1 860	2 260
16	May 25	2 420	520	1 190	880
17	May 26	337	676	438	505
18	May 27	582	1 800	928	747
19	June 6	3 300	3 000	2 100	2 300
20	June 7	2 000	800	1 100	3 000
21	June 8	800	585	600	500
22	June 9	1 390	4 900	3 400	1 240
Average of tests number 13–22		1 515	1 830	1 330	1 400
Average of tests number 3–22		2 118	2 183	....	....

* Omitted from averages.

In the first place it will be noted that the machines were not badly contaminated since but four tests showed counts in excess of 10,000 per c.c. If Test No. 5 is excluded, the average counts of the four milkings are all less than 2200 per c.c. Contaminations

of the amount noted would not be troublesome in the production of Grade A milk.

In these tests there was no progressive decrease in the germ content of the water in successive milkings even where four successive milkings were made on the same unit. Thus in the 19 tests where two successive milkings were made, the average counts were 2118 and 2183 respectively. In 10 of the 19 tests where four successive milkings were made, the averages were 1515, 1830, 1330 and 1400, respectively.

Source of the bacteria in the Station machine.— Before attempting any measures for improving the bacterial condition of the machines, or allowing the attendants to know of the purpose of the work, an attempt was made to discover the exact source or sources of the bacteria. As explained on page 129, thirteen tests of four milkings each were made, and samples taken of the rinse water (1) after passing thru the teat-cups and rubber tubes, (2) after it had passed thru the head of the machine, and (3) after it had collected in the pail. The results are given in Table II.

The results secured from the analyses were somewhat irregular and the counts from the water drawn into the pail of the machines are larger than those given in Table I, the averages from the four successive milkings in this case being 8473, 3038, 3606 and 2831, respectively.

There is a very noticeable tendency for the counts from the teat-cups and rubber tubes to be less than those taken later in the passage of the water into the machine and they remained at all times less than 5000 per c.c. At first these relatively low counts were explained as indicating that many fewer bacteria came from the teat-cups and rubber tubing than from the head and pail; but later it was realized that this result may have been caused by unrepresentative sampling (see page 129). It was surprising to secure occasionally almost sterile plates from the samples taken from the teat-cups and rubber tubes.

At times there is indication of a significant contamination from both the head of the machine and the pail. The latter may be explained by the fact that they were insufficiently steamed, and were allowed to stand in a moist condition for some hours before use at a temperature which favored bacterial growth.

TABLE II.— SOURCES OF THE BACTERIA DERIVED FROM STATION MACHINE.

Agar plate counts per c.c. of sterilized water "milked" thru machines cared for in ordinary way.

Test No.	Date.	First Milking.			Second Milking.			Third Milking.			Fourth Milking.		
		Teat-cups only.	Teat-cups and head.	Entire machine.	Teat-cups only.	Teat-cups and head.	Entire machine.	Teat-cups only.	Teat-cups and head.	Entire machine.	Teat-cups only.	Teat-cups and head.	Entire machine.
	1916												
1...	June 22	2	38	2 530	20	15	2 230	5	5	730	13	5	710
2...	June 24	2	230	10 367	16	1 140	787	6	710	1 570	14	.....	1 187
3...	July 5	86	1 270	2 910	191	37	1 670	14	19	37	154	44	30
4*..	July 6	14	370	8 600	80	18	9 300	......	......	....	......	.....	....
5...	July 7	3	43	184	57	3 855	4 900	2	3 080	10 300	28	407	10 900
6...	July 10	6	400	8 700	28	1 260	5 100	2	1 640	13 000	7	.....	1 350
7...	July 11	740	8 400	23 600	500	1 020	2 275	146	450	4 900	1 710	600	430
8...	July 19	95	940	840	2 340	11 200	1 260	58	44 400	4 070	129	340	4 100
9...	July 20	1 680	11 400	8 000	1 510	2 140	3 700	1 730	4 100	5 200	4 370	1 220	1 930
10...	July 24	549	7 200	6 000	346	1 570	1 820	105	540	1 010	265	247	11 300
11...	July 25	2 080	18 400	25 000	1 810	1 750	1 710	680	1 130	760	750	550	610
12...	July 26	12	125	141	185	253	65	20	24	36	67	.....	49
13...	Aug. 4	1 500	1 110	4 800	1 150	520	1 640	203	16 000	1 660	1 520	380	1 380
	Ave.......	564	4 144	8 473	686	2 065	3 038	248	6 008	3 606	752	†421	2 831

* Test No. 4 omitted from averages as it was incomplete. † Only nine tests in average.

Sterilization of the machines.— At this time, the cleaning and handling of the machines was taken over by one of us (R) and an attempt made to completely sterilize one of the units. The results showed that by taking extreme precautions and by separating the rubber parts completely and placing them in relatively strong chloride of lime solution or in a 2 per ct. montanin solution, sterile water could in most cases be drawn into the machines and still remain practically sterile. A few tests however showed counts between 350 and 500 per c.c. (Tables XVII and XVIII) when there was no apparent reason for the increase in count. A suggestion made at the time that these increases might be due to the occasional failure of the trap (Fig. 8) to entirely prevent the return of condensation water from the vacuum piping into the pail of the machine, led to further tests.

Entrance of condensation water from the vacuum pipes into the pail as a source of bacteria.—As has been stated (pages 123–4), the investigations made by Stocking and Mason on B-L-K machines resulted in the insertion of a cotton filter at the junction between the connecting hose and the vacuum pipes. These investigators report that the use of the filters led to a lessening of the germ content of the milk drawn, which they attribute in their papers to the filtering effect of the cotton on the air which enters when the vacuum is broken, altho from private correspondence it is clear that they also had in mind the fact that the presence of cotton in the filter prevented the return of iron rust from the piping system.

In the earlier work at this Station, machines were used which had cotton filters of the type used by Stocking and Mason; and as a result of new analyses made at that time these filters were enlarged.

After this work and before the present studies were undertaken, Moak had found that badly contaminated condensation water from the vacuum piping was still a real cause of trouble. As a result of experimental work by the manufacturers of the machines, the cotton filter at this point (Fig. 7) was entirely discarded and a suction trap (Figs. 8 and 9) inserted. The condensation water which returns from the pipes collects in the bottom of this trap and no air is allowed to pass back into the pail thru this opening. A valve (Fig. 9, vacuum relief valve) placed on the head of the machine at another place is used in relieving the vacuum in the pail when milking is finished.

In order to satisfy ourselves that this trap is necessary, heads of the older type were used on our machines where the pail of the machine was replaced by a glass jar. The glass jar and all other parts of the machines were sterilized as perfectly as possible, and the success of the sterilization was tested by analysing samples taken from five liters of sterile water drawn into the machine from the artificial udder. On the first trial, the germ count was 15 per c.c., and on the second trial 9 per c.c. showing that the sterilization was practically complete.

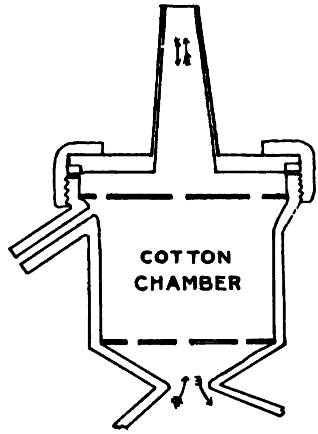

FIG. 7.—SUCTION TRAP—OLDER TYPE.

The procedure followed in carrying out the two tests was to break the vacuum thru the teat-cups after the five liters of sterile water was drawn into the glass jar and take a sample from the jar; then the milking was started again and stopped by breaking the vacuum thru the stanchion hose in the ordinary way after which a second sample was taken.

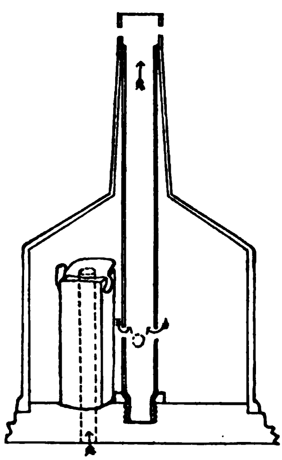

FIG. 8.—SUCTION TRAP—NEW TYPE.

Observations made thru the glass jar when the vacuum was broken thru the stanchion hose at the end of the first test showed that between 3 and 5 c.c. of condensation water was forced back thru the cotton filter by the inrush of air and the cotton was left nearly dry. The germ content of the water in the jar was raised by this contamination from 15 per c.c. to 39,000 per c.c. showing that this contamination was a serious one.

On the second trial the amount of water forced back thru the cotton filter was much less than in the first trial and the germ content was only raised from 9 per c.c. to 320 per c.c.

These variable conditions agree with other observations made in the Station stable where it has been found that the traps collect

very variable quantities of water during milking, the amounts varying from a few drops to as much as 10 c.c. The drain pipes on the vacuum lines discharge as much as 50 to 100 c.c. of water each day after milking is completed.

Numerous analyses were made of this drip water and of the condensation water in the trap. In almost all cases the germ content of the drip water and of the condensation water exceeded 1,000,000 per c.c. and frequently exceeded 10,000,000 per c.c. (maximum, 95,000,000). Because of these findings, an attempt was made to sterilize the piping by drawing a solution of chloride of lime thru the pipes. After repeated tests extending over several weeks, it was found that a certain improvement in conditions could be secured in this way; but that the bacteria very quickly reestablished themselves in the piping.

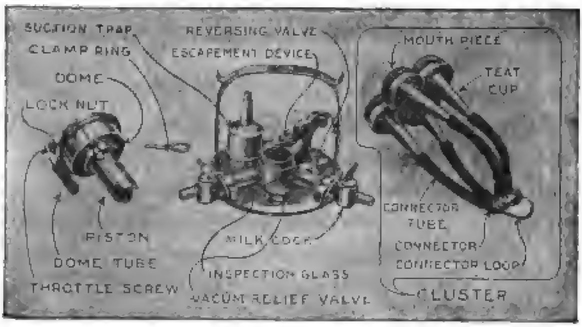

FIG. 9.—DETAILS OF THE BURRELL-LAWRENCE-KENNEDY MILKER.
Pulsator, Head, Teat Cups and Connector.

Meanwhile, tests were made to determine whether the trap (Fig. 8) absolutely prevented the return of this condensation water. In these tests, water was milked thru the machine from the artificial udder, while at the same time varying amounts of a methylene blue solution were placed in the trap. A piece of clean cotton was placed below the trap in the pail of the machine in order to reveal the presence of any methylene blue which might pass thru into the pail.

In no one of forty tests was there the slightests evidence of leakage. On the contrary the methylene blue solution largely passed up thru the connecting hose into the iron piping. While this makes it therefore very probable that this trap is efficient under all conditions, yet there remains a slight possibility that the unexplained increases in count of a few hundred per c.c., which were noted when all sources of contamination were supposed to be eliminated, came

from such leakage. The increases came at very irregular intervals and were only noted four times in making 144 tests (see Tables X, XI, XVII and XVIII).

Every effort should be made in milking machine construction to protect this opening into the pail, not only in machines of the B-L-K type but in all suction type machines. Undoubtedly the improvements in germ content after the introduction of a cotton filter at this point noted by Stocking and Mason and in the earlier work done at this Station were due to the partial protection from the condensation water offered by the cotton.

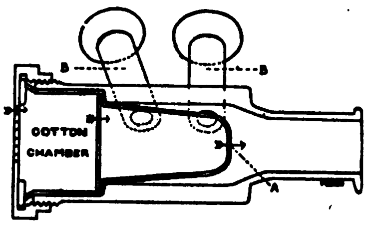

FIG. 10.— B-L-K TEAT-CUP CONNECTOR IN SECTIONAL VIEW

Stable air as a source of bacteria.— Air has frequently been regarded as a source of a significant contamination of machine-drawn milk. In the present type of B-L-K machine, air comes in contact with the milk in two places. One at the relief valve placed on the "connector" at the base of the teat-cups (Fig. 9 and Fig. 10). Here a pin hole opening (Fig. 10, A) allows air to enter continuously during milking. When the pulsator on the head of the machine shuts off the vacuum in the connecting tube, the vacuum in the teat-cups is entirely relieved thru the air entering at this point. The second point of entrance for air is the "vacuum relief valve" (Fig. 9) placed on the head of the machine. This is opened at the completion of the milking process in order to relieve the vacuum in the pail and allow the cover to be raised.

Four series of tests were conducted to determine the amount of the contamination of the milk from these two sources. Aeroscopes developed in earlier investigations at this Station[46] (Fig. 11) were used in the tests as filters for removing all of the bacteria from the air as it entered the machine at the two release valves mentioned


FIG. 11.— STANDARD AEROSCOPE.

[46] See footnote 1, fourth reference.

above. Two to three times the standard amount of fine sand was used as a filtering layer as it was feared that the passage of the rapid air currents thru the sand would spoil the efficiency of the filters; and in the first ten tests the aeroscopes were used in tandem in order to make sure that the first sand layer was an efficient filter.

The first series of tests were made in the stable with the cows in their stalls; but not while actual milking was in progress. The results given in Table III were secured during artificial milking.

TABLE III.—AMOUNT OF CONTAMINATION DERIVED FROM THE AIR DURING ARTIFICIAL MILKINGS.

Test No.	Air Sampled at Vacuum Relief Valve in Head of Machine.				Air Sampled at Relief Valve on Teat-cup Connector.			
	Plate Count		Total count per machine	Count per c.c. milk.†	Plate Count		Total count per machine	Count per c.c milk.†
	First aeroscope.	Second aeroscope.*			First aeroscope.	Second aeroscope.*		
1.....	29	0.7	290	.06	231	0.3	2310	.46
2.....	51	0.3	510	.10	129	2.0	1290	.26
3.....	99	2.0	990	.20	85	1.0	850	.17
4.....	99	0.7	990	.20	47	0.7	470	.09
5.....	107	0.7	1070	.21	100	0.3	1000	.20
6.....	85	0.7	850	.17	53	0.7	530	.11
7.....	38	1.0	380	.08	62	0.0	620	.12
8.....	22	0.0	220	.04	54	0.7	540	.11
9.....	30	0.3	300	.06	28	0.0	280	.06
10.....	72	0.0	720	.14	45	0.0	450	.09
11.....	100	......	1000	.20	120	......	1200	.24
12.....	89	......	890	.18	730	......	7300	1.46
13.....	137	......	1370	.27	700	......	7000	1.40
14.....	49	......	490	.10	550	......	5500	1.10
15.....	46	......	460	.09	63	......	630	.12
16.....	31	......	310	.06	230	......	2300	.46
17.....	54	......	540	.11	250	......	2500	.50
18.....	38	......	380	.08	260	......	2600	.52
19.....	175	......	1750	.35	980	......	9800	1.96
20.....	88	......	880	.18	470	......	4700	.94
21.....	2	......	20	.004	1	......	10	0.02
22.....	11	......	110	.02	15	......	150	.03
23.....	126	......	1260	.25	139	......	1390	.28
24.....	55	......	550	.11	233	......	2330	.46
Ave..	68	0.6	680	.14	233	0.6	2330	.46

* Figures given in this column were obtained from an aeroscope attached to first aeroscope in tandem.

† Computed for five liters of milk.

As shown in the third and fifth columns the counts obtained from the second aeroscope prove the first aeroscope to have been an efficient filter, and after ten trials the use of the second aeroscope was discontinued. The total germ content of the air which entered the machine thru the " vacuum relief valve " on the head of the machine was found to vary from 20 (Test No. 21) to 1750 (Test No. 19), with an average germ content of 680. The total germ content of the air entering a single machine during milking thru the vacuum relief valve on the teat-cup connector (column 4) was found to vary from 10 (Test No. 21) to 9800 (Test No. 19), with an average germ content from both sources of 2330. If all of the bacteria from both sources were added to the five liters of water drawn into the machine the average increase would be less than one per c.c. (0.6 per c.c.).

Since this series of analyses was not carried out under actual milking conditions, another series was made during milking, the results of which are given in Table IV. Certain difficulties in securing tests under these conditions compelled the making of separate series of analyses for each of the two valves thru which the air entered. Four to five tests were made each day, and analyses of the stable air were made at the same time.

In 33 tests of the air entering thru the relief valve on the head of the machine, the lowest count obtained was 40 (Test No. 27) while the highest was 11,400 (Test No. 9), the average number being 1590. The stable air at the same time showed a germ content which varied between 49 and 670 per liter, figures which are similar to those obtained in previous work.

In thirty tests taken at the relief valve on the " connector," the germ count per machine was found to vary from 6100 (Test No. 30) to 157,000 (Test No. 19), the average count being 37,300. The stable air showed a germ content varying between 93 and 890 per liter. When the maximum and minimum figures from both valves are added the maximum figures become 168,400, and the minimum, 6140. Under average conditions a count of 38,890 would be secured per machine. These numbers when taken by themselves seem to show that the air is a significant source of contamination; but when the figures are transformed so that they may be compared with the standard unit of measurement—a cubic centimeter of milk—it is found that this impression is only an apparent one. If the number of germs given in the minimum figures are

added to five liters of milk computation shows that the germ content of the milk would be increased by 1.2 germs per c.c., while if the

TABLE IV.—AMOUNT OF CONTAMINATION DERIVED FROM THE AIR DURING ACTUAL MILKINGS.

Test No.	Air Sampled at Air Relief Valve in Head of Machine.				Test No.	Air Sampled at Relief Valve on Teat-cup Connector.			
	Aero-scope plate count.*	Total count per machine.	Count per c.c. milk.†	Count per liter air.‡		Aero-scope plate count.*	Total count per machine.	Count per c.c. milk.†	Count per liter air.‡
1...	5	50	.01	79	1..	323	32300	6.5	890
2...	25	250	.05	.....	2..	810	81000	16.2	......
3...	87	870	.17	.....	3..	668	66800	13.4	......
4...	79	790	.16	.....	4..	634	63400	12.7	458
5...	97	970	.19	49	5..	772	77200	15.4	......
6...	86	860	.17	.....	6..	190	19000	3.8	......
7...	8	80	.02	.....	7..	385	38500	7.7	250
8...	38	380	.08	.....	8..	439	43900	8.8	......
9...	114	11400	2.28	.....	9..	226	22600	4.5	......
10...	57	5700	1.14	290	10..	285	28500	5.7	......
11...	41	4100	.82	.....	11..	839	83900	16.8	......
12...	30	300	.06	.....	12..	36	36000	7.2	93
13...	58	5800	1.16	.....	13..	26	26000	5.2	......
14...	29	290	.06	.....	14..	26	26000	5.2	......
15...	139	1390	.28	213	15..	502	50200	10.0	......
16...	31	3100	.62	.....	16..	42	42000	8.4	770
17...	25	250	.05	.....	17..	47	47000	9.4	......
18...	157	1570	.31	.....	18..	44	44000	8.8	......
19...	133	1330	.27	.....	19..	157	157000	31.4	......
20...	32	3200	.64	670	20..	19	19000	3.8	......
21...	100	1000	.20	.....	21..	105	10500	2.1	530
22...	13	130	.03	.....	22..	275	27500	5.5	......
23...	23	2300	.46	.....	23..	179	17900	3.6	......
24...	106	1060	.21	.....	24..	328	32800	6.6	......
25...	145	1450	.29	53	25..	69	6900	1.4	......
26...	77	770	.16	.....	26..	385	38500	7.7	100
27...	4	40	.008	.....	27..	44	44000	8.8	......
28...	22	220	.04	.....	28..	210	21000	4.2	......
29...	49	490	.10	.....	29..	202	20200	4.0	......
30...	79	790	.16	.....	30..	61	6100	1.2	......
31...	129	1290	.26	.....	....	......	......	.....	......
32...	24	240	.05	.....	....	......	......	.....	......
33...	5	50	.01	.....	....	......	......	.....	......
Ave.	......	1590	.32	225	Ave.	......	37300	7.4	442

* Sand suspension prepared in 10 c.c. sterile water. Some plates were prepared directly for this, others were made from dilutions of 1:10 and 1:100.

† Computed for five liters of milk.

‡ Counts obtained by using standard method of air analysis.

maximum number were added the increase would be less than 34 per c.c. These figures are insignificant when compared with the much larger number of bacteria invariably present from other sources and show that machine-drawn milk is no more abundantly contaminated with bacteria from the air than is hand-drawn milk (Compare with results obtained on hand-drawn milk as given in Bulletin No. 409).

In the Empire milker because of the use of double-lined teat-cups, no air enters the machine except as the vacuum is relieved in the pail at the end of milking. As the pails are roughly comparable in size to those used in the B-L-K machines, it is presumable that the air contamination in this case compares with that found here as entering thru the relief valve on the head of the machine. The Hinman machine is so constructed that there is little entrance of air into the interior of the vacuum chamber. It is therefore apparent that the total contamination from the air in these machines is even less significant, if such a thing is possible, than in the case of the B-L-K machine. All of the air contaminations are so small in amount that they would be quite undetectable in milk.

Efficiency of cotton as an air filter.— Two series of analyses have been made to test the efficiency of the cotton filters for which provision is made in the B-L-K machines and which were designed to remove the germs from the air, entering the machine during milking. In the first series of fourteen tests, two aeroscopes attached in tandem were used; and these were connected with the vacuum relief valves in the head of the machine. A mass of cotton was placed in the first aeroscope which was similar in amount to that used in the vacuum relief valve at this point. The second aeroscope contained sterile sand as usual. After milking five liters of water thru the machine, for each of four successive milkings, the aeroscopes were brought to the laboratory and counts made in the usual way. The results given in the second column of Table V show at once that the cotton is not a perfect filter. The counts obtained, however, are not as high as those secured under similar conditions where no cotton was used (see Table III), the average germ count per machine being 680 where no filters were used as contrasted with an average of 190 per machine where filters were used. These figures indicate that the cotton removed more than two-thirds of the bacteria. An examination of the cotton itself showed that coarse particles of dust and dirt were stopped by it.

TABLE V.—EFFICIENCY OF COTTON FILTERS IN PREVENTING THE ENTRANCE OF BACTERIA DURING ARTIFICIAL MILKING.

Cotton in first aeroscope of tandem pair.

TEST No.	AIR SAMPLED AT AIR RELIEF VALVE IN HEAD OF MACHINE.		AIR SAMPLED AT RELIEF VALVE IN TEAT-CUP CONNECTOR.	
	Plate count second aeroscope.	Total count per machine.	Plate count second aeroscope.	Total count per machine.
1	7	70	17	170
2	1	10	121	1210
3	36	360	123	1230
4	33	330	244	2440
5	0.7	7	10	100
6	1	10	8	80
7	3	30	157	1570
8	42	420	200	2000
9	4	40	10	100
10	41	410	5	50
11	50	500	88	880
12	43	430	131	1310
13	1	10	1	10
14	6	60	1	10
Averages	19	190	80	800

Fourteen similar tests were made at the same time with aeroscopes attached at the relief valve on the teat-cup connector. The results are given in column four of Table V. In general they show conditions similar to those just discussed, the average germ count per machine where no cotton was used (Table III) being 2330 which was reduced to 800 per machine (Table V) where the cotton was used.

A second series of nine analyses was made in which the aeroscopes were attached to the teat-cup connectors of the machines during actual milking. In order to make conditions more nearly comparable to those which actually occur in milking, the first aeroscope in the tandem series was replaced by a teat-cup connector. The four small openings on the side of this were plugged and cotton placed in the cotton chamber (see Fig. 10). The extra connector and the attached aeroscope were then joined with the air relief valve on the teat-cup connector in actual use.

Five tests were made on the first day, the same cotton being retained in the cotton chamber during each of the five milkings; but a new aeroscope with sterile sand was inserted for each milking. Four similar tests were carried out the second day. The results of analysing the sand in the aeroscopes are given in the right and left halves of Table VI.

TABLE VI.— EFFICIENCY OF COTTON FILTERS IN PREVENTING THE ENTRANCE OF BACTERIA DURING ACTUAL MILKING.

Cotton placed in teat-cup connector attached in tandem to aeroscope.

TEST No.	Plate count from aeroscope.	Total count per machine.	TEST No.	Plate count from aeroscope.	Total count per machine.
1*	120	1200	6†	350	3500
2	186	1860	7	260	2600
3	123	1230	8	140	1400
4	92	920	9	51	510
5	780	7800	....	....	....
			Average		2340

* Cotton in connector unchanged during tests 1–5.
† Cotton in connector unchanged during tests 6–9.

The germ counts obtained, while higher than those obtained during artificial milking (compare the average of 2340 per machine, Table VI with the average of 800 per machine in Table V), are nevertheless lower than those obtained under similar circumstances where no cotton was used (compare the average of 2340 per machine in Table VI with the average of 37,300 per machine in Table IV).

The results again indicate that more than two-thirds of the bacteria were stopped by the cotton filter. Thus it is evident that the cotton filters serve a useful purpose in protecting the milk from contamination with dust and bacteria; but their importance is usually greatly overestimated. It should be remembered that the total contamination from the air is so slight when compared with the excessive contamination possible from other sources, that even the removal of all of the bacteria from the air produces an effect quite undetectable when measured by the germ content of the milk itself.

Dropping teat-cups as a source of bacteria.— In using milking machines, it inevitably happens that the teat-cups occasionally fall to the floor. Because of the suction, dirt is drawn into them at once. Those investigators who have noted this fact have agreed that accidents of this sort are a prolific source of bacteria; but apparently no direct measurements have been made to determine the numbers of bacteria thus introduced into the pails of the machines.

Experiments were therefore made in the Station stable in which five liters of sterile water was drawn from the artificial udder into carefully sterilized machines. Sterilization of the machines was accomplished by steaming the metal parts and by disinfecting the rubber parts in a strong chloride of lime solution (containing approximately 20,000 parts per million of available chlorine). The teat-cups were assembled by an operator who handled them with sterile gloves and who rinsed the assembled parts in practically sterile hot water to remove the disinfectant.

The results secured in the first milking were used as a check to determine the perfection of the sterilization of the machines. During the second milking on each day, the teat-cups were held for 30 seconds over and lightly touching the stable floor. This was previously prepared with stable materials so that it represented conditions comparable to those found in the less sanitary commercial dairies. Detailed descriptions of the materials used are given in Table VII together with the results of the analyses made. In some cases it was necessary to clean out the teat cups by rinsing them in water before the third milking on account of stoppage of the tubes with dirt. During the fourth milking the teat cups were dropped on the floor and allowed to lie on their sides in the bedding for 15 seconds.

It is believed that the tests were so arranged that they give a rough indication of the upper and lower limits of contamination to be expected when the cups are accidentally dropped on the floor. In these tests it was found that the amount of foreign matter which could be introduced into the machine, in the case of the B-L-K tubes was limited by the small bore of the 4 individual metal tubes which join the rubber tubes to the teat-cup connector (Fig. 10 B). Any appreciable amount of foreign matter in these tubes greatly retards or entirely stops the action of the machine, and they must be cleaned before milking can be resumed.

The results obtained from the analyses of the water taken from the pail after the first milking (Column 4 of Table VII) show that the machines were practically sterile since only 5 to 12 colonies developed on the agar plates per c.c. of water.

TABLE VII.—AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM DROPPING THE TEAT CUPS ON THE STABLE FLOOR.

Agar plate counts per c.c. of sterile water, "milked" thru carefully sterilized machines.

TEST No.	Date.	Water before milking.	First milking.*	Second milking.†	Third milking.‡	Fourth milking.§	Notes.
1....	1918. Mar. 20	2	8	15 900	310	250	Teat-cups cleaned after second milking. Bedding a mixture of dried cow manure, dry feed, haydust, straw, fine sawdust and fine dry soil.
2....	April 2	4	12	24 400	2 835	2 415	Teat-cups not cleaned after second milking. Bedding a mixture of sawdust and dirt.
3....	April 3	2	8	12 800	550	830	Teat-cups cleaned before second milking could be completed. Bedding of hay dust and dirt from floor in loft of barn.
4....	April 9	1	12	18 500	2 530	610	Machine not clogged and not washed out. Dirty bedding with dry manure.
5....	April 11	2	5	4 600	490	60	Teat-cups cleaned after second milking. Bedding, very dusty chopped hay.

* Sterile water "milked" thru sterile machines.
† Teat-cups held vertically over and lightly touching the bedding for 30 seconds.
‡ Teat-cups not dropped to the floor during this milking. Cleaned out where it was made necessary by the dirt clogging the tubes.
§ Teat-cups again dropped to the floor and allowed to lie on their sides in the bedding for 15 seconds.

On the other hand the number of colonies developing after the teat-cups had been dropped to the floor (Column 5) was between 4600 and 24,400 per c.c. in the five tests which were made. In the

case of the milkings made on April 9 and 11, the amount of dry matter per liter of water in the pail was determined by filtering the water thru a Gooch filter and drying to constant weight. On April 9, the amount of sediment was .014 grams per liter, while on April 11 it was .026 grams per liter. Thus it will be seen that considerable quantities of dirt were drawn into the machines. If such accidents had happened during actual milking, the milk would have been classed as very dirty. Yet from the standpoint of germ counts, the counts obtained, while large, are not excessive and do not support the idea that excessive numbers of bacteria are introduced into the machines when the teat-cups are dropped on the floor.

The conclusion that dropping the teat-cups does not produce excessively high counts is further strengthened by the results secured from the third milking (Column 6). All of these counts were much lower than those obtained during the milking in which the teat-cups were dropped on the floor (counts vary from 310 to 2835 per c.c.) showing that the numbers of bacteria were much reduced either by the rinsing of the teat-cups in water or merely by the passage of the water thru them. The highest counts were obtained during the two milkings in which the teat-cups were not rinsed out with water.

During the fourth milking (Column 7) in which the teat-cups were allowed to lie on their sides in the bedding less dirt entered the machines and the germ counts are correspondingly low, varying from 60 to 2415 per c.c.

These results appear to justify the conclusion that dropping the teat-cups on the floor of the stable produces a measurable but variable increase in the number of germs in the milk, depending upon the length of time the teat-cups lie on the floor, and upon the kind of material on the floor.

Yet after all, the number of bacteria in the water in the pails gives a very inadequate idea of the dirty conditions present. The dropping of the teat-cups produces results which are objectionable more because of the dirt and filth thus introduced into the milk than because of the contamination of the milk with bacteria.

Discussion of results.— The foregoing results indicate that, at the Station, no one part of the milking machine was constantly the most important source of bacteria, the total amount of bacterial contamination never becoming very bad at any time. Frequently

the rubber tubing and teat-cups contributed a large part of the total contamination, but the pails and heads of the machines were usually fully as important as sources of bacteria.

There is no good reason why the metal parts of the machines should contribute large numbers of bacteria under any condition as they may be kept practically free from bacteria either by scalding and thoro drying, or by steaming. The sterilization of the rubber tubing, on the other hand, is only possible by means of special methods, since scalding and steaming are not applicable to ordinary rubber.

The stable air which enters the B-L-K machines during the milking process was found to contribute relatively insignificant numbers of bacteria to the milk, the increase in count never exceeding 34 per c.c. under the conditions tested. It is probable that even this small number would be still less in some other types of machines where smaller amounts of air come in contact with the milk. The cotton filters used on the B-L-K machines as a means of removing bacteria from the air were found to be partially effective as filters, removing the coarse dust particles and more than two-thirds of the bacteria.

On the other hand it was found that the very noticeable effect of the large cotton filters used on the head of the older types of machines should be attributed to their action in partially preventing the return of the highly contaminated condensation water from the vacuum piping. The entrance of small quantities of this condensation water into the pail was found to cause very noticeable increases in count. The suction trap which has been substituted for the cotton filters on the latest types of B-L-K machines appears to be entirely efficient in preventing the return of the condensation water, severe tests having failed to reveal any positive proof of leakage.

Dropping the teat-cups on the floor, with the resultant introduction of dirt into the pails of the machines, was found to be objectionable both because of the amount and character of the dirt and filth introduced in this way as well as because of the increase in the germ content thus produced. The germ counts did not increase as much as might have been expected as they did not exceed 25,000 per c.c. under very bad conditions.

EFFECT OF MILKING MACHINES IN USE ON ORDINARY DAIRY FARMS UPON THE GERM CONTENT OF THE MILK DRAWN.

In the course of this work opportunity was presented to study the germ content of milk drawn by machine under practical dairy conditions. Thru cooperative agreement with two local milk companies, the Geneva City Board of Health, and the dairy farmers of the vicinity, the Station undertook an experiment in the control of city milk supplies which began Feb. 1, 1915. A test has been made of the microscopic method of analysing milk samples in the preliminary portion of this work, and the results secured have already been discussed in Bulletin No. 443 of the Station. During the period previous to April 1, 1917, milking machines were in operation for part or all of the time on six of the 44 dairy farms which sent milk to the City of Geneva. Between April 1, 1917, and Dec. 1, 1917, four additional farmers installed milking machines, making a total of ten farmers using mechanical milkers who have come under the direct observation of the Station.

Detailed accounts of the conditions noted on the original six farms are given in Bulletin No. 443 and will not be repeated. A comparatively small percentage (14.22 per ct.) of the 11,851 cans of milk examined [47] were found to contain bacteria in excess of 1,000,000 individual bacteria per c.c. (approximately the same as an agar plate count of 200,000 per c.c.). About one-fifth (345 cans) of the 1682 cans containing this relatively large number of bacteria were found to contain nearly pure cultures of bacteria of the type associated with infected udders (garget). The excessive numbers of bacteria in the remaining 1337 cans appeared to be largely derived from the direct contaminating effect of utensils, tho the growth of bacteria in the milk played a noticeable role in increasing the numbers of bacteria under favorable conditions.

The milk cans appeared to be the utensils which ordinarily caused the trouble; but there was reason for thinking that the milking machines frequently caused very large bacterial contamination of the milk.

In three instances, records were secured by weekly inspection of each can of milk delivered which indicated the bacterial quality of both hand-drawn and machine-drawn milk from the same farm.

[47] Analysis principally made by J. D. Brew. A few were made by W. D. Dotterrer.

In the case of Dairyman A, the installation of a milking machine caused no marked change in the quality of the milk produced. There was on the other hand a very noticeable improvement in the quality of the milk sent by Dairyman B, after the machines were discarded; but since this was associated with improved cooling of the milk and other changes, it is probable that the improvement was in part due to other things than discarding the machines. Dairyman D sent milk of much improved quality after machine milking was discontinued and the surrounding circumstances indicated that this improvement was connected with the change in the method of milking.

In a list of 44 men, the highest rank secured by any of those who used machines was 17th place. The others ranked 21, 33, 40, 41, and 42, respectively. A comparison between the bacterial quality of 3013 cans of milk from the *nine farms sending the poorest quality of hand-drawn milk,* and that of the 3051 cans of milk examined from the *six farms sending machine-drawn milk* showed that the two groups of farmers sent milk containing approximately equal numbers of bacteria. As a class, those men who had milking machines sent milk containing more bacteria than the milk sent from the farms where hand milking was practised.

Another fact worth noting in this connection is that in the case of all but one of these farms (and that the one that stood the highest in rank) the milking was all done by hired labor. In general the machines were installed on the largest and best equipped farms where there were herds of more than 15 and less than 50 cows.

"Two of the four herds from which milk containing streptococci (bacteria associated with garget) were milked by hand and two were milked by machine. The machine milker was discarded at one of the two latter farms partly because of a belief that it caused garget. Nevertheless, so far as the records of the milk examinations show, the garget cleared up at the farm where the machine milking was continued just as quickly as at the farm where it was discarded. Both farms occasionally brought milk containing many streptococci, during the year that followed."

During a supplementary period from April 1, 1917, to Dec. 1, 1917, not discussed in Bulletin No 443, these farms and four additional farms where milking machines have been used have con-

tinued under observation.[48] Dairyman A, who stood in 17th place in the first list of 44 dairymen, dropped to 28th place in a new list of 36 men, having delivered milk which graded both absolutely and relatively poorer in bacterial quality. On the other hand, Dairyman E who stood in 41st place in the old list, secured 29th place in the new list, having improved the quality of his milk both absolutely and relatively. Dairyman C who had 33d place in the old list dropped to the very bottom of the new list of 36 men, having delivered milk of much poorer quality than during the previous period. Dairymen B, D and F either discontinued the sale of milk or the use of the machine during this period.

The six men who have used machines during part or all of the 8 months ranked 6, 28, 29, 34, 35 and 36 in the list of 36 men, thus showing a very decided tendency to deliver milk containing more numerous bacteria than did their neighbors who did their milking by hand. A seventh dairyman (J) using a milking machine, who delivered milk for only five months of the period, produced the poorest quality of milk that has been received at any time during 34 months.

In addition to the information gathered in the course of the experimental milk control work done in the City of Geneva, one or more visits have been made to eight of these farms on which machines were in use, for the purpose of testing the antiseptic solutions in use and to determine the amount of bacterial contamination of the machines. Process samples of the milk itself were taken at some of these places, while at all of them from four to eight milkings of sterile water from the artificial udder were made.

Dairyman A was visited Aug. 22, 1916, and was found to be using a Hinman milking machine and keeping the teat-cups and tubes in a solution of brine and chloride of lime. Tests showed only a trace of available chlorine in the solution. At this time, two milkings of sterile water were made successively thru a single unit after it was prepared as usual for milking. This unit was in good condition as the water from the pail showed a plate count on agar of only 1050 and 1190 per c.c. (see Table VIII). Samples taken as this water entered the pail (Fig. 3) showed that the greater part of these bacteria were already in the water before it entered the pail (see Table VIII).

Process samples taken at this time gave a count of 1770 per c.c. for the milk as drawn from the udder of a cow (see Table IX) while milk from the same cow gave a count of 5800 per c.c. as taken from the pail of the machine. The mixed milk of several cows gave a count of only 6100 per c.c. as taken from the final container, a 40-quart can.

Samples of the antiseptic solution taken on Oct. 13, 1917, showed only a trace of available chlorine in a solution of about 14 per ct. salt.

[48] Analyses of milk during the period were made by J. D. Brew and H. Macy.

On a third visit made, Oct. 31,1917, two successive milkings of sterile water thru two different units showed agar plate counts varying from 45,600 to 124,600 per c.c. (Table X). Again the larger part of the bacteria were found to be in the teat-cups and tubes. These were not in as satisfactory a condition as at the time of the first visit. This finding corresponds likewise with the fact that this dairyman made a poorer showing in the quality of his milk as delivered in the City in 1917 than in 1916. Tests of the antiseptic solution showed about 12 parts per million of available chlorine in a 14 per ct. brine.

Dairyman C was visited August 29, 1916, and found to be using a Hinman milker and keeping the teat-cups and tubes in a solution prepared from a proprietary germicide (Bacilli-Kil). Two milkings of sterile water thru the same unit gave counts of 170,000 and 36,000 per c.c. for the water in the pail, while samples taken as the water entered the pail showed counts even higher than these (Table VIII) which indicated that the bacteria were from the teat-cups and head of the unit.

Process samples of milk showed an agar plate count of 90 per c.c. for the milk as drawn from the cow into a second milking machine unit while the milk in the pail had a count of 37,000 per c.c. (Table IX). The mixed milk after reaching the 40-quart can gave a count of 51,000 per c.c. indicating that the teat-cups and tubes of the machines were responsible for the largest part of the germ content of this milk.

A sample of the antiseptic solution taken on Oct. 13, 1917, showed about 14 per ct. of salt with a very strong chloride of lime solution which tested about 1800 parts per million of available chlorine. Acting on the theory that if a little was good, more was better, this dairyman had added the entire contents of a 12 oz. can of bleaching powder to the jar in which the tubes were kept.

Two days later, two successive milkings of sterile water thru two different units showed agar plate counts varying between 66,300 and 96,800 per c.c. for the water after it reached the pail (Table X). In this case samples from the teat-cups and head of the machine indicated that only part of the bacteria came from this source and that the pail itself added bacteria in measurable numbers. The antiseptic solution tested as before except that the available chlorine had become reduced to 1700 parts per million. These results are interesting as they show that even very strong solutions of chloride of lime and brine are not in themselves sufficient to keep the tubes free from bacteria.

Dairyman E.—A visit was made August 18, 1916, and tests made of two successive milkings of a Hinman machine in use by this dairyman. The sterile water, after passing into the pails of the unit tested, gave agar plate counts of 3,174,000 and 2,516,000 per c.c., while practically identical counts were obtained from the water before it reached the pail (Table VIII), showing that these very large numbers of bacteria were practically all derived from the teat-cups and head of the machine. A chloride of lime solution containing no salt was in use. A sample tested 18 parts per million of available chlorine.

Process samples were taken from two other units at the same time. The first cow milked with one unit showed a germ content of 1130 per c.c. for her milk as drawn into a sterile test tube and 1,003,000 per c.c. (Table IX) after reaching the pail of the machine. The second cow gave milk with a germ content of 780 per c.c. which was increased to 900,000 per c.c. by the time it reached the pail of the machine. A sample taken from the 40-quart can used as the final container gave a count of 1,350,000 per c.c.

On Oct. 26, 1917, a sample of the antiseptic solution was found to contain about 14 per ct. of salt and enough chloride of lime to give a solution with 106 parts per million of available chlorine.

The following day two successive milkings of sterile water were made with each of two units and gave very irregular results (Table X) which are difficult to interpret. These varied between 1500 and 600,000 per c.c. for the samples taken from the pails of the machines while those taken as the water entered the pail varied from 6,400 to 19,400 per c.c. It is not certain, however, that these lower counts indicate that the principal contamination came from the pails themselves because of the fact that the dairyman had kept his teat-cups and tubes in a much stronger chloride of lime solution than that ordinarily used. Since it was not the practice on this farm to rinse the

teat-cups and tubes after being taken from the solution and before use, some of this strong chloride solution was present in the tubes when milking was started and must have effectively reduced the bacterial count in the first milking of water thru each unit, at least. However, only a trace of chloride could have been present, as otherwise the water would have been much more completely sterilized.

TABLE VIII.—AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM COMMERCIAL DAIRY FARM MACHINES.

Agar plate counts per c.c. sterilized water milked thru machines.

Dairyman.	Farm No.*	Date.	First Milking.		Second Milking.		Type of machine.
			Teat-cups, tubes and head.	Entire machine.	Teat-cups, tubes and head.	Entire machine.	
		1916					
A.....	17	Aug. 22	2 170	1 050	400	1 190	Hinman
C.....	33	Aug. 22	195 000	170 000	40 000	36 000	Hinman
E.....	41	Aug. 18	3 500 000	3 174 000	2 310 000	2 516 000	Hinman
F.....	42	Aug. 25	1 200 000	1 188 000	743 000	629 000	B-L-K
J......	....	Aug. 24	....	1 462 000	....	621 000	Empire

* As given in Bulletin No. 443.

While it is probable that these counts are somewhat too low for the reasons just mentioned, it should be noted that the lower counts found on this visit as compared with those found the year previous correspond also with the fact that the milk sent from this farm was of better quality during 1917 than in 1916.

TABLE IX.— BACTERIAL CONTAMINATION OF MILK DERIVED FROM MACHINES AND OTHER FARM UTENSILS.

Agar plate counts per c.c. of milk. Not from the units used for results given in Table VIII.

Dairyman.	Date.	Strippings of cow.	From pail of machine.	From carrying pail.	After passing thru strainer and over aerator.	From 40-quart can.
	1916					
A........	Aug. 22	1 770	5 800	4 800	....	6 100
C........	Aug. 22	90	37 000	34 800	59 000	51 000
E........	Aug. 18	*955	†952 000	1 016 000	1 180 000	1 350 000
F........	Aug. 25	2 170	239 000	243 000	291 000	273 000
J........	Aug. 24	4 090	1 095 000	1 267 000	1 046 000	1 012 000

* Average from two cows; 1130 and 780 per c.c.
† Average from two machines; 1,003,000 and 900,000 per c.c.

Dairyman F.— Only one visit was made to this farm for the purpose of testing the machines. This was made on August 25, 1916, and two tests were made on a single unit of the B-L-K machine. The water was caught and sampled as it entered the pail by the use of the device shown in Fig. 8, B. The water after passing the teat-cups, tubes and head of the machine gave counts of 1,200,000 and 743,000 per c.c., respectively (Table VIII), while counts from the pail were of about the same size. The antiseptic solution was stated to contain about 12 per ct. of salt and chloride of lime. Tests, however, showed only a trace of available chlorine. This herd was sold soon afterward and no further tests were made.

Dairyman G.— An Empire milking machine was in use at this place. A sample of the antiseptic solution in use was collected June 11, 1917. This contained no salt but did contain available chlorine from the chloride of lime added to the extent of 888 parts per million.

A visit was also made on November 3, 1917, and two successive milkings of sterile water were drawn into each of two units. The count obtained varied from 200 to 5500 per c.c. (Table X) showing the machines to be in excellent condition. This

TABLE X.—AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM COMMERCIAL DAIRY FARM MACHINES.

Agar plate counts per c.c. sterilized water milked thru machines. Two units tested in each case.

DAIRYMAN.	Date.	FIRST MILKING.		SECOND MILKING.		Type of machine.
		Teat-cups, tubes and head.	Entire machine.	Teat-cups, tubes and head.	Entire machine.	
	1917					
A.........	Oct. 31	33 800	45 600	24 100	95 300	Hinman
		139 600	124 600	27 500	57 700	
C.........	Oct. 15	16 400	90 000	66 300	83 700	Hinman
		41 300	96 800	6 300	66 200	
E.........	Oct. 27	6 600	34 500	6 400	600 000	Hinman
		19 400	1 500	9 000	27 900	Hinman
G.........	Nov. 3	....	5 500	....	1 090	Empire
		....	480	....	200	
H.........	Nov. 8	....	16 600	....	....	Empire
		....	6 000	....	6 300	
I.........	Nov. 14	....	Less than 600	....	Less than 400	Empire
		....	Less than 450	....	Less than 150	
J.........	Nov. 2	....	59 300 000	....	16 000 000	Empire
		....	4 200 000	....	8 300 000	

corresponds with the excellent record of this farm which was the best of any of those that came under observation.

Dairyman H.— A visit was made to this farm on November 8, 1918, and tests made on two units of the Empire milker as before. The water after reaching the pail

of the machine gave counts which varied in three milkings from 6000 to 16,600 per c.c. (Table X). The antiseptic solution consisted of brine to which chloride of lime was added. A sample showed the available chlorine present to be 35 parts per million.

Dairyman I.— One visit was made to this farm on November 14, 1917, and two units of the Empire milker, tested. Two successive milkings of sterile water thru each gave the lowest counts secured on any farm, all of them being less than 600 per c.c. (Table X). The brine and chloride of lime solution showed about 16 per ct. of salt and about 35 parts per million of available chlorine.

Dairyman J.— A visit was made on August 24, 1916, and two successive milkings of sterile water thru a single unit of the Empire machine were made. The water in the pail was found to give counts of 1,462,000 and 621,000 per c.c. (Table VIII). The tubes were said to have been boiled once daily and kept in an antiseptic solution at night.

Process samples taken on the same day showed a germ content of the milk from a single cow to be 4090 per c.c. as drawn into a sterile test tube and 1,095,000 per c. c. after reaching the pail of the milking machine unit (Table IX). The mixed milk in the final container gave a count of 1,012,000 per c.c.

On November 1, 1917, a sample of the antiseptic solution then in use was secured and tests showed it to contain about 14 per ct. of salt with 106 parts per million of available chlorine. On the next day two successive milkings of sterile water were made with each of two units which gave counts varying between 4,200,000 per c.c. and 59,300,000 per c.c. The reason for these very high counts was not evident but they correspond exactly with the condition noted in the milk itself, as it was delivered in the city. At this time nearly every can of milk from this farm showed millions of bacteria in every c.c. It is worth noting that these counts, which were the highest obtained under any conditions, were obtained from the same type of machine with which the best results were obtained.

From the tests of commercial dairies it appears that dairies using milking machines tended to produce milk containing more bacteria than dairies where the milking was done by hand. On six farms where direct comparisons between hand-drawn and machine-drawn milk were possible, only two of them (Dairymen A and G) produced milk by machine with as few germs as were contained in the milk produced by them by hand. The milk from these farms would have satisfied the bacterial standards ordinarily set for Grade A pasteurized market milk. The remaining four men (Dairymen B, D, H, and I) delivered milk of poorer bacterial quality during the period when they practiced machine milking than when they practiced hand milking. In one of these cases, however, the deterioration in quality was not great (B) and the improvement noticed when hand milking was reintroduced was associated with other changes which may have been in large part responsible for the lessened number of bacteria in the milk. In the remaining three cases the deterioration in quality, associated with the period of machine milking, was marked. It is significant that not one of the dairymen produced milk of markedly better quality when machine milking was practised.

Looked at superficially, these results indicate that machines are even yet scarcely successful from the standpoint of a bacteriologist since these farmers, to a certain extent, had the benefit of personal advice from members of the Station staff. Observation has shown, however, that because of lack of convenient facilities, cleaning the machines with hot water, or even with cold water, has been inadequately done, and that the teat-cups and rubber hose have not been taken apart and given a thoro cleansing as frequently as once a week, the period used at the Station and which is known to give satisfactory results (see pages 177–9). The machines have been found in very uncleanly condition on all of the farms where poor results were obtained.

Likewise, directions in regard to using antiseptics have not been followed, the dairyman's unfamiliarity with the action and purpose of these solutions frequently leading him to neglect essential directions. This was particularly true in regard to chloride of lime solutions where failure to keep the solutions up to the proper strength was frequently observed. The attempt of one dairyman (C) to meet this situation by using a very strong solution of chloride of lime resulted in showing that strong germicides alone are not sufficient, a result which is entirely satisfactory as all will agree that physical cleanliness as well as freedom from bacteria is highly desirable.

It is significant that this failure to keep the machines clean is associated with another condition, namely that on the farms of Dairymen B, D, H, and I, as well as on all of the other farms where relatively poor results were secured, the milking was done by hired labor in almost all cases. On some of the larger farms this was distinctly high grade labor but on others it consisted of very ordinary and indifferent persons who had no direct interest in maintaining the machines in good condition. The best results were secured on the farms where both the dairyman and his wife were thoroly interested in securing good results, and did the work themselves.

IV. MILKING MACHINES: METHODS OF MAINTAINING IN A BACTERIA-FREE CONDITION.

INTRODUCTION.

As shown in the previous pages, milking machines as used by dairymen under practical conditions are sometimes maintained in excellent bacteriological condition; but frequently are badly contaminated so that milk drawn thru them contains very large numbers of bacteria. Methods for overcoming this difficulty by means of antiseptics have been previously studied and are in practical use on the majority of the farms where machines are in operation. In spite of this, however, not all practical dairymen have succeeded in getting as good results with the antiseptic solutions as were indicated under experimental conditions; and there has also been some confusion brought about by the fact that different investigators have not secured entirely harmonious results.

Because of these things comparative tests have been made of a number of the suggested antiseptics or antiseptic measures that have been recommended. References to the previous work have already been made (pages 116–125). It will be sufficient for our purpose here to mention the various substances which have been tried and found sufficiently valuable to have been used under practical conditions.

As was natural, when suction machines were first introduced attempts were made to keep the rubber tubes and teat-cups in satisfactory condition by using hot water or steam, or by boiling them. There is almost universal agreement that these methods were either ineffective or were destructive of the rubber parts. This caused a search for more useful methods, and led to immersing the tubes in water, and to the use of harmless antiseptics.

Both early workers (Erf,[49] and Stocking and Mason[50]), as well as later ones (Wing,[51] and Larsen, White and Fuller[52]), have found that formaldehyde will keep the tubes in a satisfactory condition; but agree in declaring it to be unsuited for use because of its poisonous nature. Erf[53] and others have found lime water a satisfactory

[49] See footnote 7.
[50] See footnote 9.
[51] See footnote 20.
[52] See footnote 21.
[53] See footnote 7.

antiseptic and this has been extensively used under practical conditions. Hastings and Hoffman [54] have made the most extensive tests of this substance tho Hooper and Nutter [55] have also reported favorably upon it in a more recent work.

Brine was apparently first brought into use in connection with milking machines by the manufacturers of the B-L-K machine and was reported upon favorably by Stocking and Mason,[56] and later in more extended tests made at this Station.[57] This solution has also been used extensively under practical conditions. Hoffman-Bang [58] has used hot brines.

The work of Miss Wing [59] called attention to the usefulness of bleaching powder (chloride of lime or calcium hypochlorite) and, since her report, this substance, because of its known effectiveness as a germicide and known harmlessness has been generally used, sometimes alone and sometimes in brines. Moak,[60] in particular, has tried brine and chloride of lime in connection with the production of certified milk. He has likewise obtained good results from the use of a proprietary product "montanin," but has not recommended its general use.

In this connection it should be noted that two recent European reports (Williams, Golding and McIntosh,[61] and Burri and Hohl [62]) upon tests of milk drawn by a suction type of milking machine show good results even where no antiseptics are used. In the machine tested (the Omega) the amount of rubber tubing and of parts not sterilizable by steam is reduced to a minimum.

In recent years, without recommendation from any of the investigators mentioned, there have come into quite extensive use certain proprietary antiseptics or germicides which have been so used because of liberal advertising. The majority of these are in reality solutions of calcium or sodium hypochlorites similar in their action to the much cheaper chloride of lime or bleaching powder (calcium hypochlorite).

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[54] See footnote 10.
[55] See footnote 23.
[56] See footnote 9.
[57] See footnote 16.
[58] See footnote 18.
[59] See footnote 20.
[60] See footnote 26.
[61] See footnote 19.
[62] See footnote 27.

PRESENT STUDIES.

The usefulness of brine as a solution in which to keep the teat-cups and rubber tubing.— Since 1909, when a report on the action of 10 per ct. brine was published, brine solutions were in use at this Station until 1916. In fact the original solution was kept in use all of these years, being maintained in volume and strength by adding more salt or water as needed. The cleanliness of the solution was maintained by drawing off the precipitate or sludge from the bottom of the tank. The original solution contained 10 per ct. of salt but the amount was gradually increased until the solution contained between 12 and 13 per ct. of salt, at which strength it was maintained until discarded.

Between 1907 and 1916 nearly five hundred analyses were made of the germ content of this brine, about one-half of which were made by J. K. Wilson, formerly assistant bacteriologist at the Station, and about one-half by one of us (R). The results of these analyses will not be given in detail since no good purpose would be served by so doing, but several conclusions can be drawn as a result of the work which are of general interest.

The germ counts were found to vary greatly from day to day, showing less than one thousand colonies developed on agar per c.c. of the brine on one day, while on the succeeding day, the analyses might show more than 10,000 or even 100,000 colonies per c.c. The number of colonies as found by the agar plate method varied between none and 11,000,000 per c.c. of brine, usually, however, being more than 10,000 and less than 200,000 per c.c.

The numbers of colonies appearing on plates made from the same dilution were usually approximately the same; but counts made from plates prepared from successive dilutions frequently did not agree. Thus on Feb. 5, 1913, the brine was plated on lactose agar in dilutions of 1:10, 1:100, and 1:1000. The resulting count from the first dilution was 108,550, that from the second dilution was 58,400, while that from the third dilution 3000 per c.c. On Nov. 13, 1913, the brine was plated on gelatin and many very fine colonies developed on the plates made from the undiluted material, the number as estimated by means of a microscope being 134,000 per c.c. However, the count from the plates made from a dilution of 1:10 was only 560 per c.c., while no colonies developed on the plates

made from the 1:100 dilution and only an occasional colony on the plates made from the 1:1000 dilution.

Numerous results similar to these were obtained from lactose agar, 10 per ct. salt agar, and 10 per ct. salt gelatin. These results indicate the presence of large numbers of organisms which do not grow. No plating technique was developed which proved satisfactory, nor could satisfactory microscopic preparations be made because of the presence of the salt. The real number of bacteria in the solution was therefore undetermined, but the results showed that large numbers of living organisms were present.

A true brine flora was present as was shown by fishing colonies from the plates. Three types of bacteria seemed to predominate which were found to be capable of growth on agar slants containing from 10 to 25 per ct. of salt. The less numerous flora did not grow on agars containing more than 5 per ct. of salt. The true brine organisms isolated were (1) a short thick rod (2), a long slender rod, and (3) a large long rod. The first two were the predominant organisms on the plates from which they were isolated, while the third was abundant, but not the predominant organism on the plates from which it was isolated. Another predominant type was a large coccus which usually occurred in pairs, or tetrads with the adjacent sides of the individuals somewhat flattened. Microscopic examination showed it to be abundant in the brine from which it was obtained.

Organisms similar to these were also isolated directly from a lump of salt from a barrel of salt in use at the time. The organisms were secured by putting a small piece of salt, taken from the interior of a lump with aseptic precautions, into a tube of sterile broth. When the latter became turbid, it was plated on salt-agar and the colonies fished and examined. This suggests that the source of the brine flora was the salt itself. (Compare also Wolff [68].)

The organisms isolated as described above when inoculated into sterile milk and sterile litmus milk and incubated for three weeks at ordinary temperatures, did not produce any noticeable changes and there was but little evidence of growth. Presumably, then, even if these organisms are present on the teat-cups and tubes they are of no significance in the milk, and may not even grow on the agar plates from which milk counts are ordinarily made.

[68] Wolff, A. Prüfung des Molkerei-Salzes. *Milchw. Zentralbl.*, 43:545-551. 1914.

During all of the period in which this brine was in use at the barn, milk of high keeping quality was continuously produced at the Station, and such analyses as were made of the general supply rarely gave agar plate counts in excess of 10,000 per c.c. Owing to this fact, and to the extensive studies which have been made upon brine, no further studies have been made since 1916. In passing, it should be noted that our observations, while agreeing with the two tests given by Hooper and Nutter[64] in showing the brine solution to contain many bacteria, do not give support to their contention that brine is therefore unsuited for use in connection with milking machines.

Methods used in study of antiseptics other than brine.— In comparing the efficiency of various antiseptics other than brine, one or more pairs of teat-cups have been kept in the solutions under test, for periods varying in time from a few weeks to several months. The teat-cups were kept in daily use for milking while the tests were in progress, were rinsed daily as described (page 132) and were thoroly scrubbed once per week.

In determining whether any particular solution was satisfactory, tests were made by "milking" five liters of sterile water thru the machines, the metal parts of which had been steamed. Frequent testing showed this steaming to be sufficient to practically sterilize the metal parts. The count obtained by making agar plates from the water drawn into the pail of the machine was therefore assumed to indicate the bacterial condition of the tubes. No attempt was made to protect the sterile water from air contamination other than to do the work in a moist milk room where the air was known to be nearly sterile. Under these conditions, the number of bacteria derived from this source must have been negligible (see pages 139–143).

Complete sterilization of machines by use of steam and chloride of lime.— For the sake of comparison and in order to satisfy our own curiosity, an attempt was made in 1916 to draw sterile water into a sterile machine. In order to secure a sterile machine a combination of steam and special cleanliness was used on the metal parts and all of the rubber parts were separated and placed in antiseptic solutions.

The machines, which had been in use for months previously, were first taken apart by one of us (R) and the separate metal and rubber

[64] See footnote 23.

parts given a thoro cleansing. The metal parts, except the pail, were then sterilized under 15 pounds pressure in an autoclave, while the rubber tubing was placed in a very strong chloride of lime solution (the solution in this case probably contained about 20,000 parts of available chlorine per million).

Just before the regular afternoon milking, the rubber parts were rinsed thoroly in boiling water and then the various parts of the teat-cups were assembled, sterile rubber gloves being used to protect these parts from contamination from the operator's hands. At the two places where air entered the machines (relief valve on teat-cup connector and vacuum relief valve on the head, Figure 9), aeroscopes were attached so that the air was filtered thru a layer of sterile fine sand which had been tested and found to be an effective bacterial filter.

After five liters of sterile water had been drawn into the machine, samples were taken and analysed, the results being given in Table XI.

TABLE XI.— AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES WHEN THESE WERE CAREFULLY STERILIZED. CHLORIDE OF LIME USED AS GERMICIDE ON RUBBER TUBES.

Agar plate counts per c.c. sterilized water milked thru machines.

TEST NUMBER.	Water before milking.	First milking.	Second milking.	Water before milking.	Third milking.	Fourth milking.
1	1	5	2	1	4	5
2	5	63	13	10	13	9
3	1	7	6	....	5	4
4	4	4	8	5	6	16
5	4	13	16	4	43	14
6	2	1	2	15	3	6
7	3	7	....	1	5	16
8	3	25	15	3	15	8
9	0	2	1	1	10	6
Averages	2	14	8	5	12	9

In the third and sixth columns of this Table, the counts obtained from samples of the sterile water are given. These show that a few colonies developed on the agar plates. It should be remembered, however, that these plates were held in the incubator first for five days at 21° C. and later for two additional days at 37° C.

Under these conditions some contaminations introduced from the air during plating are sure to develop no matter how perfectly the plates are protected. The averages of 2 and 5 colonies per c.c. on these plates represent the total contaminations from these sources.

In the columns given under the headings, "First," "Second," "Third" and "Fourth" Milkings, the figures represent the number of colonies developed per c.c. of the sterile water after it was drawn into the pail of the machine. It will be seen at once that there was a slight increase in number of colonies above the 2 and 5 per c.c. developed from the contaminations just mentioned. The largest number of colonies found was 63 per c.c., this number being developed from a sample of the first milking made on Oct. 4. In some cases, however, no colonies developed from the water in the pail, showing that our object had been accomplished and that the water had been drawn into the pail without the slightest contamination. The averages secured for the four successive milkings of 14, 8, 12, and 9 per c.c., moreover, show that contamination in all cases was practically absent. The averages from the six most successful tests of 4, 4, 5½, and 9 per c.c. were scarcely higher than the average counts from the plates of sterile water.

Not being satisfied even with these nearly perfect results and still wishing to know how great precautions were required to secure absolutely perfect results, a second series of milkings of the same sort was made in which even more extreme precautions were taken. These precautions consisted (1) in doing the work in the milk room where a moist atmosphere and freedom from dust would lessen chances of contamination from dust, (2) in making the plates, greater care was used to exclude all chances of dust contamination, (3) a stronger solution of chloride of lime was used which was tested and found to contain between 20,000 and 30,000 parts of available chlorine per million.

The results of this series of 10 milkings are given in Table XII. It will be seen at once that these extreme measures cut the amount of bacterial contamination even lower than in the former series of tests. The average count of colonies from the sterile water was only one per c.c. The highest count obtained from the water after being drawn thru the machine was obtained on the fourth milking on November 14, when 11 colonies developed per c.c. In 12 instances out of the 40 milkings no more colonies developed

from the water drawn thru the machine than from the water taken before milking, and in all of the other cases the increase was insignificant, showing that our purpose had really been accomplished and that it was possible by the use of extreme precautions repeatedly to draw sterile water into the machines and have it remain sterile.

TABLE XII.— AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES WHEN THESE WERE STERILIZED WITH EXTREME PRECAUTIONS. CHLORIDE OF LIME USED AS GERMICIDE ON RUBBER TUBES.

Agar plate counts per c.c. of sterilized water milked thru machines.

TEST No.	Date.	Water before milking.	First milking.	Second milking	Water before milking.	Third milking.	Fourth milking.
	1916.						
1.......	Sat., Nov. 11	2	2	2	0.8	2	3
2.......	Mon., Nov. 13	0.2	2	2	1.0	2	2
3.......	Tue., Nov. 14	2	5	5	2.0	3	11
4.......	Fri., Nov. 17	0.6	1	1	0.4	1	0.6
5.......	Wed., Nov. 22	0.8	0.4	0.2	0.6	0.4	0.6
6.......	Thur., Nov. 23	0.0	0.4	0.4	0.2	0.4	0.4
7.......	Sat., Nov. 25	2	0	1	0.6	0.2	1
8.......	Tue., Nov. 28	2	5	4	2	3	3
9.......	Wed., Nov. 29	0.4	0.4	1	0.2	1	0
10.......	Thur., Dec. 7	0.4	4	3	2	2	3
Averages.............		1	2	2	1	1.5	2.5

However, because the extreme precautions used are impracticable even for use on farms producing certified milk, tests were then made to find how great the increase in contamination would be under practical conditions.

Sterilization of the machines by steam and chloride of lime under practical conditions.— In the first series of tests in which chloride of lime was used as the disinfecting agent, the same machines were used; but the procedure was modified as follows: (1) the metal parts were steamed for 15 minutes daily in a steam chest and care was taken to see that they were thoroly dry as soon as removed from the steam chest, (2) the regular attendants, who cared for the daily washing of the pails and heads, and the weekly washing of the teat-cups, were asked to exercise care in cleaning these parts, (3) between milkings, the teat-cups rinsed by the usual methods (page 132) were kept at the barn in a crock containing a solution of chloride

of lime which held from 497 to 745 parts per million of available chlorine as shown by frequent tests.

In each series of tests of the bacteriological condition of the tubes, they were first rinsed thoroly with practically sterile hot water to remove all traces of the disinfectant. Eight series of milkings were made between December 19, 1916, and January 12, 1917, the first of the tests being taken after the tubes had been in use for 12 days since the preceding tests, given in Table XII. The results of the new series of tests are given as the first series in Table XIII.

TABLE XIII.— AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES, CAREFULLY CLEANED AND STERILIZED BY PRACTICAL METHODS. CHLORIDE OF LIME USED AS GERMICIDE.

Agar plate counts per c.c. of sterilized water milked thru machines.

TEST No.	Date.	Water before milking.	First milking.	Second milking.	Water before milking.	Third milking.	Fourth milking.
			First series.				
	1916.						
1.....	Dec. 19	0.2	2	7	2.0	5	6
	1917.						
2.....	Jan. 4	0.8	16	6	0.2	2	3
3.....	Jan. 6	0.8	4	3	1.0	6	5
4.....	Jan. 8	0.2	12	3	0.2	2	157
5.....	Jan. 9	4.0	12	10	2.0	8	11
6.....	Jan. 10	0.6	10	19	1.0	27	31
7.....	Jan. 11	0.4	5	2	0.6	3	4
8.....	Jan. 12	2.0	3	8	3.0	30	8
			Second series.				
1.....	Mon., Mar. 26	0.0	36	7	1.0	7	42
2.....	Tue., Mar. 27	1.0	46	22	0.2	18	21
3.....	Mon., April 2	0.4	13	4	0.2	35	53
4.....	Mon., April 16	0.4	15	10	0.8	21	33
5.....	Tue., April 17	1.6	15	3	0.6	7	24
6.....	Mon., May 14	5.0	79	25	6.0	32	54
7.....	Tue., May 15	3.0	71	49	5.0	40	58
8.....	Mon., May 28	0.2	14	12	1.6	7	53
9.....	Tue., May 29	0.6	11	7	......	......	....
10.....	Mon., June 11	1.2	629	345	1.2	193	224
11.....	Tue., June 12	1.0	23	4	0.0	3	2
12.....	Mon., June 25	0.4	3 008	1 637	0.2	1 082	1 139
13.....	Tue., June 26	0.6	1 526	12 306	1.2	11 620	9 632
14.....	Mon., July 9	0.8	25	680	1.4	1 020	920
15.....	Tue., July 10	3.0	11 470	4 890	1.6	3 950	2 960
16.....	Mon., July 23	3.4	49 700	25 800	1.6	28 230	24 230
17.....	Tue., July 24	0.4	179 430	92 600	1.4	53 200	55 300
18.....	Mon., Aug. 6	0.7	25 000	16 100	0.7	15 100	10 600
19.....	Tue., Aug. 7	0.3	16 900	5 100	0.3	11 800	8 600

The results of these milkings carried out under conditions regarded as practicable on dairy farms gave results which to our surprise were nearly as perfect as those obtained by the use of extreme measures. Exclusive of one count of 157 colonies per c.c. (fourth milking, January 8), the highest count obtained in any of the 32 milkings was only 31 per c.c. (fourth milking, January 10). Contamination of this amount would be insignificant even in the highest grade milk.

Feeling, however, that this short-time test was not sufficiently severe to show that equally good results could be obtained under practical conditions, the same methods of handling the machines were continued from this time until the middle of August, 1917. The steaming of the pails and heads was reduced to five minutes. Milkings of sterile water were made on Monday and Tuesday afternoons of each week. These days were chosen as the day before and the day on which the thoro weekly cleaning was given the tubes. The whole of the routine was in the hands of the regular dairy attendants except that one of us (R) cared for the strength of the chloride of lime solution. Frequent tests showed that this was maintained between 177 and 710 parts per million of available chlorine.

The results of the analyses are given as the second series in Table XIII. Inspection of this table shows that the results secured were nearly as good as those given in Table XI and in the First Series of Table XIII *until the warm summer weather began.* Late in June counts of increased size began to appear, at first somewhat irregularly, and later, as the hot summer weather came, the counts became large even reaching 180,000 per c.c. in the first milking made on July 24, 1917. This unexpected result was not correlated in any evident way with any change in conditions except the warmer temperature, the strength of the chloride solution having been constantly maintained as shown by tests of the available chlorine present.

Just as these results were secured, in a personal conference, Dr. M. J. Prucha, of the University of Illinois, suggested that in similar tests he had found that the strength of the chloride of lime solution was much weaker in the interior of the tubes than in the surrounding solution, and that this was due to the chemical action of the chloride of lime on the rubber, the reaction taking place more rapidly at warmer temperature. A preliminary account of this work has since

been published,[65] and a more complete account will be published later.

Accordingly, on August 9, a set of teat-cups was removed from the crock just before the evening milking in such a way as to retain the liquid in the tubes. By disconnecting the long tube from the teat-cups, the liquid in each of the two parts was collected separately. The solution in the crock showed 213 parts per million, the solution in the interior of the teat-cups, 168 parts per million, and the solution in the interior of the long tubes only 35 parts per million of available chlorine. Samples of these solutions plated on agar were sterile.

A second test made on the following day gave similar results showing that the solution in the long tubes was materially weaker than that outside of the tubes.

On August 1, 2, 3, and 10, tests were made to determine whether this solution was so weak that it failed to sterilize the rubber. Two sets of tubes where lifted out of the crock each day just before use in milking and brought to the laboratory, where the outer sides of the tubes were carefully rinsed with hot water, the operator using sterile rubber gloves in handling the tubes. The rubber tubing and metal parts were then disconnected and tests made as follows:

a. A liter of sterile water was poured thru each of the long rubber tubes. On August 1, the counts from this water were 229,000 and 97,000 per c.c., respectively. On the following day, the counts were 689,000 and 61,000 per c.c. while on August 3 they were 579,000 and 208,000 per c.c. In contrast to these, the August 10 tests showed less than 300 colonies per c.c. for each tube.

b. The eight short rubber tubes were placed in a flask with a liter of sterile water on each day. By pouring from one sterile flask to another these tubes were rinsed as thoroly as possible before agar plates were made. This rinse water on August 1 proved to be sterile, while the count on the following day was only 5 per c.c. On August 3, however, a count of 2570 per c.c. was obtained from this rinse water. On August 10, the count was 2 per c.c.

c. The two metal teat-cup connectors and the eight metal teat-cups were washed as thoroly as possible on each day in a liter of sterile water in a sterile pail. The counts from this rinse water were 1 per c.c. on August 1, 0 per c.c. on August 2, 2.5 per c.c. on August 3, and 4.5 per c.c. on August 10.

d. The small metal rings and rubber disks used in the mouth pieces of the B-L-K teat-cups and the rubber mouth pieces were all separated and washed in a liter of sterile water. The counts from these were 2 per c.c. on August 1, 3 per c.c. on August 2, 37 per c.c. on August 3, and 4 per c.c. on August 10.

e. The heads of the machines were tested at the same time in order to determine whether any bacteria came from these. The piston was rinsed in a liter of sterile water and one liter of sterile water was poured thru each of the two milk cocks on the head of the machine. The results in all but one case were practically sterile, the count never exceeding 7.5 per c.c. In the single exception referred to the rinse water gave a count of 148 per c.c.

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[65] Prucha, M. J., Weeter, H. M., and Chambers, W. H. Hypochlorites as a disinfectant for rubber. *Abs. of Bact.*, 2:19. 1918.

From these tests it is evident that the principal source of the bacteria was the interior of the rubber tubes, the long rubber tubes being especially contaminated with them. It is noteworthy, however, that even these were not in very bad condition on August 10. Apparently on this date the chloride of lime retained its strength in the tubes sufficiently to largely prevent growth.

The above results clearly indicate that chloride of lime solutions when used alone become weakened too quickly to make them suitable for use under practical farm conditions. This weakness is especially troublesome in hot summer weather.

Sterilization by steam and a mixture of saturated brine and chloride of lime.— In an effort to secure the advantages of both brine and chloride of lime, Miss Wing has suggested the use of a combined solution which has met with much favor. It has since been discussed by Moak and has been used extensively by practical dairymen in the State and elsewhere. In this combined solution all brine organisms are killed by the chloride of lime making a sterile solution, while the stability of the solution is secured by the fact that the strength of brines does not alter during use.

Tests were therefore made between August 20, 1917, and January 14, 1918, of solutions containing both salt and chloride of lime. A saturated brine solution was used to which one quart of a stock solution of chloride of lime was added twice per week (available chlorine in stock solution about 20,000 parts per million). In order to make the test a severe one, warm weather conditions were maintained until November 21, by keeping the crock containing the tubes in a warm place.

The temperature of the solution in the crock was usually between 20° C. and 28° C. during this period, and the chloride of lime solution lost strength rapidly, testing between 18 and 400 parts per million of available chlorine. After November 21, the crock was put in a cold place so that the temperature of the solution was reduced to a few degrees above freezing. The available chlorine increased rapidly under these conditions so that it never fell below 400 parts and even reached 1200 parts per million.

Four successive milkings of five liters each of sterile water were made on each Monday and Tuesday as in the previous work, the results of the analyses being given in Table XIV. Inspection of these results show that even under the severe test of warm conditions

the counts obtained from these tubes exceeded 100 per c.c. in only 11 instances out of a possible 64. The highest count obtained was 1920 per c.c. on the fourth milking of August 21, the second day after starting the experiment. On August 31 the water was sterile as received into the pail of the machine, the plates showing an average of less than one colony per plate.

TABLE XIV.— AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES, CAREFULLY CLEANED AND STERILIZED BY PRACTICAL METHODS. BRINE AND CHLORIDE OF LIME USED AS GERMICIDE.

Agar plate counts per c.c. of sterilized water milked thru machines.

TEST No.	Date.	Temperature of brine and chloride solution.	Water before milking.	First milking.	Second milking.	Water before milking.	Third milking.	Fourth milking.
	1917.							
1....	Mon., Aug. 20	24° C.	7	204	53	13	86	86
2....	Tue., Aug. 21	23° C.	0.8	70	235	0.6	870	1920
3....	Wed., Aug. 29	21° C.	0.3	16	4	0.7	1	1
4....	Fri., Aug. 31	20° C.	0.0	0.3	0.3	0.3	0.3	0.7
5....	Mon., Sept. 24	25° C.	0.7	12	14	1.3	20	73
6....	Tue., Sept. 25	22° C.	1.7	3	9	0.7	41	35
7....	Wed., Sept. 26	26° C.	1.7	7	4	65*	37	31
8....	Thur., Sept. 27	27° C.	0.7	77	53	0.7	12	9
9....	Fri., Sept. 28	27° C.	2.0	15	18	1.7	5	9
10....	Mon., Oct. 8	25° C.	1.0	5	5	1.3	5	5
11....	Tue., Oct. 9	26° C.	0.7	260	11	4.0	7	6
12....	Mon., Oct. 22	28° C.	0.0	27	621	0.3	359	65
13....	Tue., Oct. 23	27° C.	4.3	52	53	7.0	46	38
14....	Mon., Nov. 5	26° C.	1.7	162	108	1.0	167	380
15....	Mon., Nov. 19	25° C.	1.0	28	33	2.0	4	5
16....	Tue., Nov. 20	22° C.	0.3	9	35	0.7	2	3
17....	Mon., Dec. 10	2° C.	0.3	64	11	2.0	108	101
18....	Tue., Dec. 11	2° C.	0.3	81	76	2.0	58	20
	1918.							
19....	Mon., Jan. 14	2° C.	1.3	211	53	2.3	51	16

* Plates apparently contaminated.

The results obtained between November 21 and January 14 while the crock was kept in a cold place were similar to those obtained while it was in a warm place. Two out of twelve counts exceeded 100 per c.c., the highest count of 211 per c.c. being obtained from the first milking made on January 14.

In considering the significance of these figures, it should be kept in mind that while these milkings were all made in a milkroom where the air was free from dust, slight contaminations from this source are undoubtedly present in each case. The sterilization of the pails and head of the machine was carried out by the dairy attendants and while tests showed the steaming given to be sufficient to sterilize, there is always present the possibility that some of the bacteria were derived from these sources rather than from the teat-cups and tubes. In any case the total contaminations from the machines due to all sources was not great enough to be significant in practical dairying. It should be remembered that the entire care of the machines was in the hands of the attendants except for the maintenance of the strength of the antiseptic solution, and that nearly a year had elapsed in the course of the work since they had been requested to use special care in cleaning the machines.

Sterilization by steam and lime water:— As stated previously, several workers and many practical dairymen recommend the use of lime water as a solution in which to keep the teat-cups and tubes. Accordingly tests similar to those just described for the combination of brine and chloride of lime were carried out between August 24 and November 13, 1917.

The lime water solution was prepared by placing a relatively large amount (10 pounds) of quick lime in the bottom of a 25-gallon crock. This was slaked carefully and then the crock was filled with water. Because of this large excess of lime it was expected that a saturated solution of lime water would be maintained for a long period of time. Tests showed that when the solution was frequently stirred this purpose was accomplished.

Analyses to show the bacteriological condition of the teat-cups and tubes were usually made as before on Mondays and Tuesdays, five liters of sterile water being drawn thru the tubes into the machines. Summer conditions were maintained thruout the test by keeping the crock in a warm room where the temperature of the solution varied between 20° C. and 30° C. It was felt that this would make the test a severe one as lime is less soluble in warm water than in cold water. The results of the analyses are given in Table XV.

TABLE XV.— AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES, CAREFULLY CLEANED AND STERILIZED BY PRACTICAL METHODS. LIME WATER USED AS GERMICIDE.

Agar plate counts per c.c. of sterilized water milked thru machines.

TEST No.	Date.	Temperature lime water solution.	Water before milking.	First milking.	Second milking.	Water before milking.	Third milking.	Fourth milking.
	1917.							
1....	Fri., Aug. 24	24° C.	0.8	410	20	1.0	26	9
2....	Mon., Aug. 27	21° C.	1.0	244	30	0.8	41	28
3....	Tues., Aug. 28	22° C.	0.3	91	7	0.0	9	2
4....	Thur., Aug. 30	20° C.	0.3	30	4	0.7	2	2
5....	Sat., Sept. 1	22° C.	0.0	229	11	0.0	4	56
6....	Mon., Oct. 1	23° C.	1.0	2 270	970	2.0	1 010	1 240
7....	Tues., Oct. 2	22° C.	1.3	1 530	193	1.3	56	38
8....	Wed., Oct. 3	26° C.	0.7	910	57	3.0	24	104
9....	Thur., Oct. 4	27° C.	1.3	2 050	940	0.7	189	57
10....	Fri., Oct. 5	26° C.	3.0	580	53	.....	.....	12
11....	Sat., Oct. 6	24° C.	5.0	620	47	4.0	25	15
12....	Tues., Oct. 16	31° C.	1.3	124	25	5.0	69	110
13....	Mon., Oct. 29	26° C.	1.3	500	52	1.7	23	75
14....	Tues., Oct. 30	30° C.	0.7	73	32	0.7	28	23
15....	Mon., Nov. 12	28° C.	1.7	1 910	1 390	0.7	710	610
16....	Tues., Nov. 13	26° C.	0.7	41	35	4.0	14	13

Inspection of this table shows that practically sterile water was drawn thru the tubes in some instances, e. g. second, third and fourth milking on September 1. However, in the majority of cases, the bacteriological results, while excellent, were not quite as good as those secured when the brine and chloride of lime were used in combination under equally severe conditions. The highest counts were obtained on October 1 and 4 when two of the counts were slightly in excess of 2000 per c. c. Even counts of this size would not be significant in practical dairying so that the analyses uphold the idea that lime water is a satisfactory solution for use. No objectionable action on the metal or rubber was observed and the tubes appeared sweeter and cleaner than with the brine or with the chloride of lime solutions.

Cold running water as a means of keeping the tubes free from bacteria.— Because of the fact that it had been reported that certain practical dairymen were getting excellent results by keeping their

teat-cups and tubes in a jar which received the overflow from a cold spring, it was decided to test this system of caring for the tubes. Accordingly between April 14, 1917, and August 13, 1917, two pairs of teat-cups and tubes were kept in a crock which received a constant flow of water from a city water tap. The rate of flow was approximately 12 gallons per hour. In all other respects the tubes were handled as before. At the beginning, the temperature of the water in the jar was 6° C., but this gradually increased as the weather become warmer until in August the temperature rose to 19½° C.

After a preliminary series of analyses made daily, Monday and Tuesday analyses were made as before. The results are recorded in Table XVI. An inspection of these results shows that as long as

TABLE XVI.— AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES CAREFULLY CLEANED AND STERILIZED BY PRACTICAL METHODS. TUBES PLACED IN COLD RUNNING WATER.

Agar plate counts per c.c. of sterilized water milked thru machine.

TEST No.	Date.	Temperature. of water.	Water before milk-	First milking.	Second milking.	Water before milking	Third milking.	Fourth milking.
	1917.							
1....	Sat., Apr. 14	6° C.	1.8	132	97	1.6	113	49
2....	Wed., Apr. 18	......	1.0	72	9	0.2	9	18
3....	Thur. Apr. 19	......	3.0	263	10	0.6	7	4
4....	Fri., Apr. 20	......	0.2	.....	28	.....	245	23
5....	Sat., Apr. 21	......	0.6	51	12	0.6	77	378
6....	Mon., May 7	9° C.	7.0	385	60	1.0	98	53
7....	Tues., May 8	9° C.	0.8	231	21	0.4	18	75
8....	Mon., May 21	9½° C.	1.2	56	57	0.6	117	207
9....	Tues., May 22	......	0.2	251	37	0.2	181	348
10†...	Mon., June 4	11° C.	0.4	39	18	0.6	16	36
11†...	Tues., June 5	11° C.	0.6	238	108	0.8	50	34
12†...	Mon., June 18	13° C.	1.0	48	135	1.0	13	6
13†...	Tues., June 19	13° C.	1.2	22	3	1.0	4	1
14....	Mon., July 2	15° C.	1.4	389	17	3.0	216	60
15....	Tues., July 3	15° C.	1.2	207	29	2.0	13	9
16....	Mon., July 16	17° C.	0.6	350	255	1.8	173	108
17‡...	Tues., July 17	16° C.	1.0	340	27	0.6	14	10
18‡...	Mon., July 30	18° C.	2.0	46,850	28,500	2.0	21,870	8,280
19‡...	Tues., July 31	......	1.3	53,000	20,000	0.7	14,750	11,770
20‡...	Mon., Aug. 13	19½° C.	0.8	32,000	8,400	*19.0	38,200	10,200

* Plates apparently contaminated.

† Samples of water taken from crock gave plate counts of 9700, 3800, 4200 and 320 per c.c. respectively on these dates.

‡ Samples of water from the crock gave counts of 2585, 8500, 352,000 and 11,300 per c.c. on these dates. Samples of tap water taken on Jul. 30, Jul. 31 and Aug. 13 gave counts of 54, 61, and 136 per c.c. respectively.

the temperature of the water remained below 18° C. (62° F.), the cold water acted as an effective means of repressing bacterial growth in the tubes. The water in the pails after milking while never sterile, was in some cases almost so; e.g., the second, third and fourth milkings on June 19 where the counts were 3, 4, and 1 per c.c., respectively. The highest count obtained while the water was still colder than 18° C. was only 389 per c.c. These surprisingly low counts are as good as any obtained where chemical disinfectants were used under practical conditions.

However, as soon as the water reached 18° C., a complete change took place in the results; and beginning with July 30, much larger counts appeared. In the twelve milkings carried out under these conditions the lowest count obtained was 8280 per c. c. while the highest was 53,000 per c.c.

The plain indication from this series of tests is that this method of keeping the tubes is satisfactory *provided the water is cold enough to prevent the development of bacteria.* Where cold running water is available, this method of handling the tubes deserves further trial as it has the marked advantage of avoiding the use of antiseptics entirely. It should be noted that several previous investigators (e. g., Harrison, Hooper and Nutter, Ruediger) have experimented with cold water, but apparently not *running* water. They have in each instance reported unfavorably upon the use of water.

Sterilization of the teat-cups and tubes with "montanin."— Because of results reported by Moak with this proprietary germicide, and its entirely different chemical nature from any of the other germicides it was decided to include this in the series of tests. "Montanin" is in reality a by-product of the ceramic industries and was previously supplied from Germany, it is stated to be a mixture of hydro-fluor-silicic acid and fluor-silicates of zinc and aluminum[66]; and is used in the brewing industry for the disinfection of rubber hose, washing walls and woodwork and the like. The strength recommended for use is a 2 per ct. solution. This makes a clear, colorless, nearly odorless, slightly acid solution. No good data was secured regarding its toxicity to man, but it is probably not highly poisonous, if poisonous at all in small quantities.

[66] Wehmer, C. Versuche über die hemmende Wirkung von Giften auf Mikroorganismen. IV. Wirkung von Fluorverbindungen auf Hausschwamm, Schimmelbildung, Fäulniss und Gärung. *Chemiker-Zeitung*, 38:114–115, 122–123. 1914.

In the first series of analyses made with montanin, an attempt was made to completely sterilize the machines as in the series of analyses made where chloride of lime was used (see pages 162–5). The teat-cups and tubes were completely taken apart each day and each tube and metal piece thoroly scrubbed. The metal parts of the machine other than the large pail and piston plunger were sterilized in the autoclave under 15 lbs. pressure for fifteen minutes each day. The rubber tubing was placed in a 2 per ct. montanin solution, while the piston plunger was immersed in a 4 per ct. solution. Before testing, the operator (R) assembled the parts, using sterile rubber gloves, and rinsing each part separately in boiling hot water.

The tests were made as before, five liters of sterile water being drawn into the machines in each case. The results are given in Table XVII. On Feb. 23, the water after the first milking gave a count of 374 colonies per c.c., the reason for which is not evident;

TABLE XVII.—AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES WHEN THESE WERE STERILIZED WITH EXTREME PRECAUTION. MONTANIN USED AS GERMICIDE ON RUBBER TUBES.

Agar plate counts per c.c. of sterilized water milked thru machines.

TEST No.	Date.	Water before milking.	First milking.	Second milking.	Water before milking.	Third milking.	Fourth milking.
	1917						
1	Feb. 2	0.8	0.6	0.6	0.0	1.0	0.4
2	Feb. 10	1.0	0.2	0.8	0.4	8.0	3.0
3	Feb. 14	0.4	0.6	0.0	1.0	2.0	1.0
4	Feb. 15	0.0	0.8	0.4	0.0	0.2	0.4
5	Feb. 16	1.0	0.2	0.4	0.2	0.6	0.2
6	Feb. 21	0.2	0.6	0.0	0.0	0.2	2.0
7	Feb. 23	0.2	374.0	0.2	0.2	1.0	2.0

but with this exception the results from the 28 milkings indicated that the machines were even more perfectly sterilized in this case than where the chloride of lime was used. (Compare with Tables XI and XII).

Because of these excellent results it was decided to try out this germicide under practical conditions. Consequently this solution was put into use between Feb. 27, 1917, and March 13, 1917, at the barn, a 2 per ct. solution being used in the crock and the teat-cups and tubes being handled by the regular dairy attendants, as in the

other similar series. The tests were made before the important effect of temperature on the action of some of these germicides was fully appreciated and the solution was cold in all cases.

The results from a series of 38 milkings are given in Table XVIII. In none of these did the germ content of the water in the pail of

TABLE XVIII.—AMOUNT OF BACTERIAL CONTAMINATION DERIVED FROM STATION MACHINES CAREFULLY CLEANED AND STERILIZED BY PRACTICAL METHODS. MONTANIN USED AS GERMICIDE.

Agar plate counts per c.c. of sterilized water milked thru machines.

TEST No.	Date.	Water before milking.	First milking.	Second milking.	Water before milking.	Third milking.	Fourth milking.
	1917						
1.....	Tues., Feb. 27	0.8	5	1	0.2	3	2
2.....	Thur., Mar. 1	0.6	12	6	......	......	.....
3.....	Fri., Mar. 2	0.8	11	496	0.4	24	420
4.....	Tues., Mar. 6	0.8	19	8	0.0	4	7
5.....	Wed., Mar. 7	2.0	20	4	1.0	4	11
6.....	Thur., Mar. 8	4.0	93	16	1.0	9	63
7.....	Fri., Mar. 9	0.2	4	1	0.0	1	0.6
8.....	Sat., Mar. 10	1.0	4	2	1.0	2	1
9.....	Mon., Mar. 13	0.0	19	18	0.4	12	5
10.....	Tues., Mar. 14	2.0	2	490	0.2	2	0.6

the milker exceed 500 per c.c., and in only three instances did it exceed 100 per c.c. In many cases the count from the water after being drawn into the pail was so low as to indicate that the teat-cups and tubes were sterile. In general the bacteriological results were fully as good as any secured.

Certain other considerations, however, make the use of this otherwise excellent germicide of doubtful desirability. Tests showed that, if the tubes were not thoroly rinsed after being taken from the solution and before use in milking, the small quantity of solution left in the tubes produced a noticeable and undesirable " tinny " and somewhat " pungent " taste in the milk. If large quantities of the solution were left in the tubes there might even be enough of the acid solution to curdle the fresh milk in the interior of the tubes. In the face of the known carelessness of many practical dairymen in rinsing the tubes it was felt that these conditions make it undesirable to recommend this solution for general use. This is the more true because of the lack of satisfactory evidence to show the

harmlessness of montanin. Fortunately there appears to be little danger of the fraudulent use of this germicide in milk itself as very small amounts added to milk give unpleasant tastes which make the milk unsalable. Some metals are attacked by montanin tho the rubber remained unaffected even when used for a much longer period than that noted above.

Conclusions in regard to chemical antiseptics.— In the foregoing study it has been shown that by simple and inexpensive means, it is possible to keep the teat-cups and rubber tubes of milking machines in a germ-free or nearly germ-free condition. That is, by immersion in brine, in cold chloride of lime solutions, in brine and chloride of lime combined, in lime water, in cold running water, or in montanin, these tubes *may* be made as nearly sterile as an ordinary dairy utensil can be made by steaming or scalding accompanied by drying. It should be noted, however, that all of these tests were made on machines *thoroly and copiously rinsed after each milking by clean, cold water, hot soda water, and hot water and that regularly once per week the teat-cups and tubes were completely taken apart and thoroly washed.* Observations made under practical farm conditions give clear indications that the antiseptics described do not give equally good results on machines which are cared for in a less satisfactory manner than this.

Mechanical cleaning of the teat-cups and tubes.— Early in the experimental work on milking machines at this Station, after tests had been made upon the bacteriological condition of the machines, it became the custom to clean the teat-cups and tubes thoroly only once per week. Such apparent carelessness has been criticized by others who have based their judgment upon the fact that ordinary metal utensils must be thoroly cleansed after each use.

In view of this criticism, a large part of our tests with the various antiseptics have been made upon Mondays, the day before the thoro cleaning and Tuesdays, the day on which the thoro cleaning was given. These data have been retabulated in Table XIX. In all there are 31 comparisons given with eight milkings in each.

In 15 of these the counts obtained from the water in the pail were appreciably higher on Mondays than on Tuesdays. Ten pairs of counts show the reverse condition, while the remaining six gave practically identical counts on both days. This result might be held

TABLE XIX.—BACTERIAL CONTAMINATION OF STATION MACHINES ON THE DAY BEFORE CLEANING TUBES CONTRASTED WITH THAT ON THE DAY ON WHICH THE TUBES WERE CLEANED.

Agar plate counts per c.c. of sterile water milked thru machines.

Test No.	Date.	Germicide in use.	Monday Tests. Day Before Cleaning.				Tuesday Tests. Day on Which Cleaned.				Averages.	
			Milking No.				Milking No.					
			1	2	3	4	1	2	3	4	Mon.	Tues.
	1916											
1	Jul. 10–11	Weak chloride of lime	8,700	5,100	13,000	1,350	26,000	2,275	4,900	430	7,038	8,401
2	Jul. 24–25	Ditto	6,000	1,820	1,010	11,300	25,000	1,710	760	610	5,033	7,200
3	Oct. 16–17	Strong chloride of lime	7	......	5	16	25	15	15	8	9	16
	1917											
4	Jan. 8–9	Ditto	12	3	2	157	12	10	8	11	44	10
5	Mar. 26–27	Weak chloride of lime	36	7	7	42	46	22	18	21	23	27
6	Apr. 16–17	Ditto	15	10	21	33	15	3	7	24	20	12
7	May 14–15	Ditto	79	25	32	54	71	49	40	58	48	54
8	May 28–29	Ditto	14	12	7	53	11	7	......	......	21	9
9	June 11–12	Ditto	629	345	193	224	23	4	3	2	348	8
10	Jnne 25–26	Ditto	3,008	1,637	1,082	1,139	1,526	12,306	11,620	9,632	1,716	8,771
11	July 9–10	Ditto	25	680	1,020	920	11,470	4,890	3,950	2,960	661	5,818
12	July 23–24	Ditto	49,700	25,800	28,230	24,230	179,430	92,600	53,200	55,300	31,990	95,132
13	Aug. 6–7	Ditto	25,000	16,100	15,100	10,600	16,900	5,100	11,800	8,600	16,700	10,600
14	Aug. 20–21	Brine and chloride of lime	204	53	86	86	70	235	870	1,920	107	774
15	Sep. 24–25	Ditto	12	14	20	73	3	9	41	35	30	22
16	Oct. 8–9	Ditto	5	5	5	5	260	11	7	6	5	71
17	Oct. 22–23	Ditto	27	621	359	65	52	53	46	38	268	47
18	Nov. 19–20	Ditto	28	33	4	5	9	35	2	3	18	12
19	Dec. 10–11	Ditto	64	11	108	101	81	76	58	20	71	59
20	Aug. 27–28	Lime water	244	30	41	28	91	7	9	2	86	27
21	Oct. 1–2	Ditto	2,270	970	1,010	1,240	1,530	193	56	38	1,372	454
22	Oct. 29–30	Ditto	500	52	23	75	73	32	28	23	162	39
23	Nov. 12–13	Ditto	1,910	1,390	710	610	41	35	14	13	1,155	26
24	May 7–8	Cold running water	385	60	98	53	231	21	18	75	149	86
25	May 21–22	Ditto	56	57	117	207	251	37	181	348	109	204
26	June 4–5	Ditto	39	18	16	36	238	108	50	34	27	108
27	June 18–19	Ditto	48	135	13	6	22	3	4	1	51	8
28	July 2–3	Ditto	389	17	216	60	207	29	13	9	171	65
29	July 16–17	Ditto	350	255	173	108	340	27	14	10	222	98
30	July 30–31	Ditto	46,850	28,500	21,870	8,280	53,000	20,000	14,750	11,770	26,375	24,880
31	Mar. 12–13	Montanin	19	18	12	5	2	490	2	1	14	124

	Mon.	Tues.
Ave. of 22 tests in which all counts were less than 1,000 per c.c.	91	85
Ave. of remaining 9 tests	10,227	17,920
Grand ave. of 31 tests	3,033	5,263

to indicate that there was a slight advantage to be gained in washing the tubes more frequently.

On the other hand, the grand average of all the Monday tests was 3033 per c.c., while that of the Tuesday tests was 5263 per c.c. An examination of the table will show that the difference between the averages is very largely produced by the tests made on Monday, July 23, and Tuesday, July 24, 1917. The four Tuesday counts in this case averaged 95,132 per c.c. as contrasted with an average for the four Monday milkings of only 31,990 per c.c. However, even if this test is omitted in the average, the results were still slightly higher for Tuesday than for Monday.

In the face of these analyses, the only conclusion which can be drawn is that there was no measurable difference between the bacteriological condition of the tubes on the days when they were thoroly washed and the condition of the same tubes after six days of use. Observation showed, however, that the tubes were cleaner on Tuesdays than on Mondays, and that there was real reason for the thoro cleaning as frequently as once per week. More frequent cleaning requires extra labor and is at the same time destructive of the rubber tubing.

Germ content of water after the first, second, third and fourth milkings. — In our observations on the bacteriological condition of milk from farms where milking machines were in use, it has been frequently noted that the germ content of all the different cans of milk produced would be approximately equal. This was surprising as it might be expected that because of the rinsing of the machines by the milk, the cans last filled would have many fewer bacteria. In the course of our experimental work, four successive milkings have been made of sterile water thru the machines in almost all instances.

The results obtained from all of these successive milkings have been divided into two groups. One group in which none of the counts exceeded 1000 per c.c. and a second group in which were placed counts in excess of 1000 per c.c. The grand averages of the four successive milkings of the 81 series of counts in the first group were 114 per c.c. for the first milking, 49 for the second milking, 37 for the third milking and 50 for the fourth milking. This would indicate a slight reduction in the number between the first and second milkings, with but little further reduction in the case of the later milkings. In the case of the results from the more badly

contaminated machines it is seen that there was a regular reduction noted when the averages of the 16 tests are examined. The average count from the first milking was 26,671 per c.c., from the second milking, 13,734, from the third milking 12,728 and from the fourth 9218. This percentage reduction is not as great, however, as might have been expected and is less than that noted by Prucha, Weeter and Chambers,[67] who have made tests of successive rinsings of badly contaminated milk cans. These findings indicate that the bacteria are not as readily loosened from the surfaces of the teat-cups and tubing as from smooth metal surfaces.

DISCUSSION AND CONCLUSIONS.

In the foregoing studies it has been found that while the bacterial condition of the machines in use at the Station and at some of the commercial dairy farms in the vicinity of Geneva was always at least reasonably satisfactory and usually excellent, the bacterial condition of the machines at the remaining commercial farms was very unsatisfactory. In many of the latter cases the machines themselves were found to contribute millions of organisms per c.c. of sterile water drawn thru them as in ordinary milking.

The chief sources of this heavy seeding with bacteria are the teat-cups and rubber tubes. The difficulty in maintaining these in proper condition lies in the fact that, being partially made of rubber tubing, they cannot be satisfactorily cleaned by ordinary methods of washing and scalding.

During the course of the experimental work the usefulness of the commonly used and recommended antiseptic solutions have been tested upon the station machines. In this connection, it cannot be too strongly emphasized that our machines were constantly maintained in a cleanly condition. While satisfactory results were obtained with these clean machines it does not necessarily follow that equally good results would have been obtained with dirty machines. In fact all of the observations indicate that physical cleanliness of the machines cannot be neglected if good results are desired.

The antiseptic solutions tried have been (1) 10–13 per ct. brine, (2) chloride of lime solutions of varying strength, (3) chloride of

[67] See footnote 2.

lime in a saturated brine, (4) lime water, (5) cold running water, and (6) a proprietary germicide sold under the trade name of "montanin."

Satisfactory results have been secured with all of these. However, with both ordinary chloride of lime and with running water, it was found that they became ineffective during hot weather. Certain considerations, moreover, make some of the solutions less desirable than others.

In the case of brine it has been found to contain large numbers of bacteria. Since, however, these appear to be very largely salt organisms which do not have any significance in milk, very satisfactory results are secured from its use. The great advantages of brine are that it is easily and cheaply prepared and does not lose its strength during use. Sterile brine solutions can be obtained by adding chloride of lime to the brine, and in this way the advantages of both substances are secured without additional disadvantages. Constant attention is required, however, if the strength of the chloride of lime solution is to be maintained, and this is especially true in hot weather.

Excellent results were secured by the use of running water so long as its temperature remained lower than 18° C. (62° F.). Under certain circumstances where the overflow of a cold spring of pure water is available this method of keeping the tubes is worthy of further trial.

The montanin was only tested to a limited extent and not under the most severe conditions. It was found to be very effective so far as tried. Because of unpleasant tastes in the milk where a montanin solution was carelessly used, its action on many metals, and doubtful desirability, this solution is not recommended for general use.

The usefulness of lime water was found to be much as reported by others. The bacterial contamination in the tubes was low at all times, tho not quite as low as where the mixture of brine and chloride of lime was used. For this as well as for other reasons, the authors of this paper believe the mixture of chloride of lime and saturated brine to be the most satisfactory one to recommend for general use.

QUESTIONS CONCERNING THE CONTROL OF A CITY MILK SUPPLY ANSWERED.*

ROBERT S. BREED.

It is not the purpose of the present bulletin to enter into a discussion of the many and varied economic and public health questions concerning public milk supplies that are attracting the attention of all citizens in the State; but rather to give answers to certain definite questions that have arisen in connection with an attempt to establish an adequate control over the milk supply of Geneva.

As early as 1907, members of the Station staff realized the desirability of undertaking the control of a city milk supply as an experiment, and in that year began a cooperative effort with the city of Geneva. The earlier part of the experiment was continued from 1907 to 1911 when cooperative effort was discontinued for a time only to be renewed again in 1915, and continued until the present. The results secured from these studies have been published in Bulletins Nos. 337, 363, 398, 439 and 443.

Experiments of a nature similar to the one undertaken by the Station are being carried on by others at the present time showing the general appreciation of their value. Among the more noteworthy of these are:

(a) One started in 1917 which is supported by funds given by the Metropolitan Life Insurance Company, and carried out under the control of the National Association for the Control and Prevention of Tuberculosis. This experiment has for its object not only the control of the milk supply of a small city but also all sources of tuberculosis. The field of work selected by the Association is Framingham, Mass. A preliminary report of this experiment has already been published[1]; (b) one started by Dr. H. A. Harding of the Illinois Agricultural Experiment Station in 1918 where the field

[1] Armstrong, D. B. Framingham Monograph No. 1, General Series, I The Program. Community Health Station, Framingham, Mass. 1918.

* Reprint of Bulletin No. 456, December, 1918.

of work is Champaign, Ill.[2]; (c) one started in 1918 under the direction of Mr. K. E. Miller of the U. S. Public Health Service, Acting Health Officer for Edgecombe Co., N. C., which is important in that it is one of the earliest instances in which a town or city has undertaken the pasteurization and distribution of its milk supply. The field of the experiment in this case is Tarboro, N. C., and a preliminary account of the work has just been published.[3]

These experiments are noteworthy in that they indicate an increasing realization of the need of working out the problems involved in establishing a satisfactory, and yet not financially burdensome control of city milk supplies by the experimental method. The experiments are, in each case, under the direction of men specially trained for the work, accustomed to controlling experimental work and to analyzing results in a critical way, and the men are furnished with facilities and funds sufficient for the work. In all cases the field chosen for work is a town or small city where conditions can be more satisfactorily controlled than in larger communities. From them and from similar efforts, the public has a right to expect information of value in working out the economic and public health questions that are under discussion at the present time.

THE MILK SUPPLY OF GENEVA.

Geneva is a city of approximately 14,000 inhabitants, and is fairly typical of the smaller cities of the State. Before the experimental studies of the milk supply were started in 1907, the milk supply for the city came from 40 farms in the neighborhood on which about 550 cows were kept. The milk was delivered largely by the individual producers, and none was pasteurized before delivery. Since April 1, 1909, however, the larger part of the milk has been delivered by two milk companies both of which have maintained central pasteurizing and distributing plants within the city limits. Pasteurization was at first accomplished by the flash process, but since 1914 this has been by the holding process in conformity with the State Sanitary Code. At no time within the past four years has the amount of pasteurized milk sold been less than 95 per ct. of

[2] Harding, H. A. Simplified City Milk Inspection. Report of International Association Dairy and Milk Inspectors for Chicago (1918) meeting.

[3] Miller, K. E. Safe Milk for the Small Town. Public Health Reports, 33:2213–2217. 1918.

the entire supply, and during periods of several months at a time the only unpasteurized milk sold in the city has been a few quarts a day sold by the companies at the request of individual physicians.

With the gradual increase in the population since 1907, the number of farms supplying milk has increased from 40 to 55, while the number of cows on these farms has increased to approximately 820 animals. The sale outright of six of the largest herds during the past two years and the reduction in size of other herds due largely to opportunities of engaging in other more profitable lines of agriculture, has caused the milk companies continually to expand their field of supply until now milk from 13 of these farms is shipped to the city by rail from points not more than 25 miles distant. Supplies necessary to meet temporary shortages have been obtained from several different milk stations located within a radius of 50 miles of the city.

A QUESTIONNAIRE CONCERNING THE GENEVA MILK SUPPLY.

1. Is the milk supply watered or skimmed by either of the milk companies? No. Under present conditions of inspection and of modern business conditions as they exist in Geneva, no dairy company could afford to run the risk of losing its business reputation by such practices even if the men in charge were willing to countenance dishonest practices.

2. Is the milk ever watered or skimmed before it reaches the pasteurizing plants? Occasionally, yes.

3. What is being done to protect the city against these fraudulent practices? Before the city undertook the maintenance of laboratory inspection in July, 1917, the only protection was that given thru the occasional visit of an inspector from the State Department of Agriculture, this Department being entrusted with the enforcement of the State law. Since a city analyst has been appointed, chemical analyses have been made, and, wherever watering or skimming has been indicated, the attention of the State inspector has been called to the matter, and this inspector has visited the farms in order to secure the evidence necessary for legal prosecution.

4. Do farmers generally approve skimming and watering of milk? No. The officers of the local Dairymen's League approached the city officials as soon as they learned that watered milk had been detected

and wished to expel the offenders from the League. Thus far, it has not been felt necessary publicly to disgrace the two or three men involved.

5. If these things are true, why do bottles of milk as delivered in the city frequently fail to show a distinct cream line or any marked amount of cream? There are two reasons for this:

(a) The contracts between the dairy companies and the farmers have been so worded that the milk was bought (and this still holds true) on a per-quart or a per-100-pounds basis with little regard to the food value of the milk. Naturally all dairymen who run their farms on a business basis have introduced cattle giving low test milk, as these animals ordinarily give the largest number of quarts at a minimum cost of production. As a result, all of the large herds in the vicinity of Geneva give milk which is low in fat and other milk solids. On the other hand, the companies have been able to buy enough milk from small herds where the milk had previously been used for butter making or where, for other reasons, low test animals have not been introduced to bring the average quality of the city supply above 3.8 per ct. fat. Since, however, it is not possible to mix the milk thoroly at the receiving plant, some customers receive thinner milk than do others.

(b) However, the more common reason why the pasteurized milk delivered in Geneva shows an indistinct cream line or even little cream at all is because the milk is at times unintentionally or even purposely heated above the 142° to 145° F. for 30 minutes required by the State Sanitary Code.[4] The milk is thereby more certainly freed from all living disease germs without being injured in food value. However, the creaming ability of the milk is impaired when over-heating occurs, and it may even possess a detectable cooked flavor. Not very long ago a rather widespread complaint was made to the health officer that the milk as delivered had very little cream on it. An analysis, however, showed that the milk contained 4 per ct. fat. Without question the chief reason for the lessened cream and indistinct cream line was faulty pasteurization.

6. Would it not be fairer to the dairyman, and tend to secure richer milk if the companies bought the milk according to its food value, paying a premium for rich milk? Yes, and the purchase of milk on this basis would also lessen the temptation for the dairyman to water or skim his milk.

[4] Chap. III. Milk and cream. N. Y. State Department of Health. 1915.

7. Why is this method of payment not followed? Largely because under present conditions it is cheaper for the companies to buy the milk at a flat rate. They buy as cheaply as possible with little regard to the food value of the milk because they know from experience that the public is more sensitive over a rise in the price of milk than over a reduction in food value. In other words, the popular demand at the present time is for cheap milk.

8. How much more should the consumer expect to pay for a milk testing 4.5 per ct. fat than for a milk testing 3.5 per ct. fat? Under prevailing prices the former milk is worth about 1¼ cents per quart more than the latter.

9. How can the housewife tell whether she is obtaining as rich a milk as she is entitled to for the price paid? There is no simple way in which to determine this, as it requires a chemical analysis.

10. What protection does the State give its citizens at this point? The only law is one which makes 3 per ct. fat and 11.5 per ct. total solids the minimum for normal milk. The general effect of this law in New York, as elsewhere, has been to put a premium upon cows producing low test milk causing a general reduction in the quality of the milk produced in the State. Many students of the milk question believe that this situation would be much improved if the milk distributors were required by law to place a guarantee upon their labels, stating the minimum amount of fat present in the milk. Pure food laws based on this principle have been found both workable and effective in the case of other food products. Customers must, however, be prepared to pay more per quart for rich milk than for thin milk.

11. Is the milk supply of Geneva safe to use for baby feeding? Milk is subject to so many possible sources of infection and may be so misused after delivery at the homes that no one could safely guarantee the quality of an entire city milk supply. So far as it is possible to judge from the records of inspection, it appears that the Geneva supply compares in quality with that sold elsewhere in the State under the label "Grade A pasteurized."

12. Is pasteurized milk as good for babies as unpasteurized milk? Babies differ and doctors disagree. Unpasteurized milk, of a quality permitting it to be sold as Grade A raw can be obtained on physicians' request to either milk company or from the one dairyman licensed to sell Grade A raw.

13 Why is the milk sold under a Grade B label if of Grade A quality? Briefly, this is because the dairymen would need to expend both money and labor in order to bring their barns up to the standard required, and they would in return demand the price asked for Grade A milk. It is doubtful whether the changes would produce any measurable improvement in the quality of the milk.

14. Is the inspection of the Geneva supply carried out efficiently and economically? More than 6,000 samples of milk have been collected by the sanitary inspector during the past year, and these have been examined by the city bacteriologist. Wherever milk has been detected which was not up to the standard in quality of Grade A milk, inspections and special analyses have been made in order to find the exact cause or causes of the difficulty. The matter has then been explained to the person or persons at fault, with the result that the trouble has usually been corrected. In one case the milk was excluded from sale in the city. The correction of these troubles has necessitated the making of many special visits to the dairy farms in addition to the annual inspection visit required by the State Sanitary Code. Only part of the expense of this work has been borne by the city, as the Station has supervised the work and has given the city the free use of its laboratory in return for the use of the data collected.

15. How does the dairy inspection work of Geneva compare with that of other cities in the State? According to the records published[5] by the State Department of Health, only two cities in the State, New York and Buffalo, report having examined more than 6,000 samples of milk during 1916 or 1917 (the latest years for which figures are obtainable). Syracuse and Jamestown both report having examined approximately 3,000 samples yearly. Other cities either make no report or have examined fewer than this number of samples. It should, however, be explained that the chief reason why two persons in Geneva giving only part time to the work of milk inspection have examined so large a number of samples in comparison with other laboratories with a larger working force is because the

[5] Wadsworth, A. B. The Laboratory Service of the State of New York. Health News, N. S., 11:159–169. 1916.
Lawrence, J. S. The Laboratory Service of the State of New York. Heath News N. S., 12:249–257. 1917. Issued by the New York State Department of Health.

majority of the samples have been examined microscopically and not by the more commonly used plate method.

16. Are the records secured by microscopic examination of milk as valuable as are the records secured by the more generally used method? The records secured by microscopic examination of fresh milk samples taken from individual cans as received at the pasteurizing plants, when accompanied by age and temperature records, show not only the amount of bacterial contamination of the milk, but also give a surprisingly accurate idea of the cause or causes of excessively high counts. The records obtained from examining this type of samples are not only more easily obtainable, but are also more valuable than the records which would have been obtained if the officially recognized method had been used. On the other hand, it is impossible to determine the efficiency of pasteurization by microscopic examination of the milk, so that samples taken from the pasteurizers have been examined by the plate method.

17. Why is the price of milk in Geneva, two, three or even more cents per quart higher than in some of the neighboring towns and cities? As explained, all of the milk sold in Geneva is in reality of Grade A quality. There is no city in this part of the State, and probably none in the State, where the entire supply is of so high a quality. Only three cities in the immediate neighborhood, Rochester, Syracuse and Ithaca, maintain a laboratory inspection of their milk supply and in these cities the price of milk, of a quality equal to that sold in Geneva, has been about the same as, or more than, that in Geneva. During the month of December the price of Grade B pasteurized milk in New York City has been two cents and the price of Grade A pasteurized milk four cents more per quart than in Geneva.

In the smaller cities and towns about Geneva where the price has been less than in Geneva, the larger part of the milk is, or should be, sold under the labels "Grade B raw" or "Grade C raw." These labels signify to a person familiar with the conditions that the milk is practically unprotected from the danger of transmitting disease germs. New York City has not permitted the sale of these grades of milk for a number of years, and several other cities of the State, including Geneva, have the same regulation.

Other considerations also affect the price difference, one being that the basal price for milk in the Geneva district is 16 cents per 100 pounds more than in the New York City district. It has been neces-

sary to pay this price in order to secure a supply, as farming lands in the vicinity of the city are readily utilized for other more profitable lines of farming. Even at this price, the companies have found it difficult to maintain their supply, and during November and December the city practically faced a milk famine. At times the companies have paid as high as an equivalent of 12 cents per quart for an emergency supply which would otherwise have gone to the city of Baltimore.

18. Does it pay to protect our milk supply in such a way as to eliminate the danger of carrying tuberculosis, typhoid, septic sore throat and other milk-borne diseases? Exact statistics cannot be presented for Geneva at this time; but there is every reason to believe that a study of the vital statistics for the city would show the same saving in lives and sickness that has been obtained in other cities where similar control measures are in force. Life insurance companies have learned that it pays in dollars and cents to them to support the efforts made to control our milk supplies.

THE MICROSCOPIC STUDY OF BACTERIA AND FUNGI IN SOIL.*

H. JOEL CONN.

SUMMARY.

1. A method of staining dried soil infusions has been devised, similar to the one already in use for milk, by means of which direct microscopic study of the bacteria in soil is possible.

2. The method has certain limitations, arising primarily from the fact that it is difficult to distinguish between the smallest soil bacteria and tiny particles of dead organic matter; but in spite of these limitations it has proved of use, first to give an idea as to the actual number of bacteria in soil, and second to furnish information as to the kinds of microörganisms that are present in soil in active form.

3. The microscope shows that the actual number of bacteria in soil is probably five, ten, or even twenty times as great as indicated by the culture plate method. The discrepancy between plate count and microscopic count is due to bacteria that do not grow on the plates rather than to the occurrence of large clumps that do not break up in the process of plating. This is shown by the fact that a large majority of soil bacteria occur singly.

4. The microscope furnishes additional evidence in confirmation of one point brought out in previous papers: namely, that the large spore-formimg bacteria (*Bacillus megatherium* DeBary and *B. cereus* Frankland, for instance), which are abundant on culture plates made from soil, actually occur in normal soil only as spores. These spores, moreover, form a very small proportion of the total bacterial flora of soil.

5. The method has not revealed the presence of fungus mycelium in any soil except where there is an unusual amount of organic matter, such as in the leaf-mold of woodland soil.

6. Filaments of Actinomycetes have been found, altho in much smaller numbers than the spores of these organisms.

7. In the case of these two groups of organisms, fungi and Actinomycetes, the plate count is not an index of activity, but of ability to produce spores. In general it may be said that when an organism is concerned that produces spores or any other resting stage the significance of the plate count cannot be determined unless the microscope is used to show whether the organism is present in active form.

INTRODUCTION.

The methods in general use for the study of soil bacteria are all cultural methods. The culture plate is used to estimate their numbers; pure culture study of the organisms isolated from soil is used

* Reprint of Technical Bulletin No. 64, January, 1918.

to reveal their individual activities; while the inoculation of sterile culture media with soil is the method used when it is desired to study mass actions of the soil bacteria. Much as these methods differ from each other, they are all cultural and therefore indirect. Cultural methods show what takes place under laboratory conditions, but furnish no direct evidence as to what occurs in nature.

In the study of pathogenic bacteria — either animal or plant parasites — there has never been any such entire dependence upon indirect evidence. Even before cultural methods of studying bacteria were devised, microscopic examination of infected tissue was common. Microscopic study alone did not solve the problems of infection; but its importance has always been so evident that even after the necessity of studying bacteria in pure culture was realized, the use of the microscope was not abandoned. Non-pathogenic bacteria, to be sure, have often been counted by means of the microscope, as recently discussed by Breed and Brew in a bulletin of this Station,[1] and in enumerating the bacteria in milk, the microscope is now used quite extensively. It is also used to some extent as a means of counting bacteria in water and in various foods. Except in pathogenic work, however, few bacteriologists have realized the full possibilities of the microscope.

The greatest limitation of the microscope in counting minute objects is well summed up by Breed and Brew, as follows: "One of the chief difficulties which is met with in using the microscope in this way has been the preparation of the substance containing the bacteria, yeasts, blood cells, and the like, in such a way as to show the objects to be counted distinctly and at the same time evenly distributed over definite areas."[2] These difficulties are harder to overcome in the case of soil than in the case of milk — to which Breed and Brew applied the microscopic method. The prospects of applying the method to soil appeared at first quite discouraging, because the ordinary bacterial stains color not only the microörganisms but also the dead organic matter and even the mineral matter in soil. By the use of the proper technic, however, as already pointed out,[3] this difficulty has been overcome, and it is now possible to make a rough estimate by means of the microscope as to the actual number of bacteria in any soil.

Quantitative estimations, however, are not the only possibilities of the microscope in studying a bacterial habitat. The successful use of the microscope in counting milk bacteria has overemphasized the quantitative side of the matter; and it must not be forgotten that another side exists. Pathologists have amply demonstrated this in their use of the microscope for the study of infected tissues.

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[1] Breed, R. S., and Brew, J. D. Counting bacteria by means of the microscope. N. Y. Agr. Exp. Sta., Tech. Bul. 49. 1916.

[2] Page 5 of reference given in footnote 1.

[3] Conn, H. J. The direct microscopic examination of bacteria in soil. *Abstr. Bact.*, 1:40. 1917.

The purpose of the present paper is to show to what uses the microscope may be put in the study of soil bacteria, qualitatively as well as quantitatively.

TECHNIC.

Preparation of soil infusion.— The first step in making microscopic preparations to show the bacteria in soil is to prepare a soil infusion that is capable of adhering evenly to a glass slide and that contains the solid matter in suspension in such a strength as not to be too opaque and yet not too dilute to show the bacteria in sufficient abundance for study. Pure water does not yield a satisfactory infusion, because it cannot be spread evenly over glass unless the glass is absolutely free from grease, and also because there is not sufficient organic matter in soil to fix the infusion to the slide upon drying. After trying various fixatives, a weak solution of gelatin has been found best, other adhesive substances such as albumin having been found to have too great affinity for the stains used.

The gelatin fixative is prepared by dissolving 0.15 g. of gelatin in 1000 c. c. of hot water. It is recommended that some gelatin be used which is put up in granular form, because of the greater ease in measuring out such a small quantity. The exact strength of the gelatin solution is quite important; if too strong it coats the soil granules with a film that stains the same color as the bacteria, while if too weak it will not adhere properly to the glass. The solution should be sterilized in a cotton-plugged flask or bottle and resterilized after each day that it has been in use. A new solution should be made up whenever the old solution is suspected to be no longer satisfactory.

The extent to which to dilute the soil in making the infusion depends primarily upon the amount of clay it contains. The infusion should be as concentrated as possible without causing the preparation to be too opaque for satisfactory study. For clay soil, which presents the greatest difficulties, a dilution of 1/10 has proved the best. Sandy soil is much more readily studied, and a greater concentration may be used, such as 1/3 or 1/5. In making the infusion, add one gram of soil to the proper amount of the gelatin solution, allowing 0.5 c. c. for the volume of the 1 g. of soil. That is, to make a dilution of 1/10, add 1 g. of soil to 9.5 c. c. of the fixative. Small glass-stoppered weighing bottles have proved very convenient for making the infusions. The soil and the fixative should be mixed in the bottle, shaken for about a minute, and the portion for examination withdrawn before the sediment has had time to settle. The glassware used should be clean, but not necessarily sterile.

Preparation of smears.— Each smear should be made from 0.1 c. c. of the infusion, measured out with a capillary pipette. A convenient form of pipette is made out of thermometer tubing with a white background, calibrated to deliver from one mark to a second mark. A pipette of much this style is furnished with Hayem-

Sahli blood counting outfits for measuring out white corpuscles, and can be used by letting the infusion run out from the 15 to the 5 cu. mm. mark. If accurate quantitative results are desired the calibration of the pipette should be tested before use.

The microscopic slides should be well cleaned and rinsed in alcohol just before using, or the infusion will not adhere properly. It is recommended that two smears be made on each slide. Each smear should be made to cover 1 sq. cm., obtaining this size by placing the drop of infusion over a sheet or plate on which square centimeter areas are drawn and spreading it out with a needle. Care must be taken to see that the visible soil particles are evenly distributed thruout the entire area. As soon as the smears are made the slides should be placed on a level surface over a water-bath of boiling water, where they will quickly dry. They are then ready for staining.

Staining.— The stain used is rose Bengal in carbolic acid.[4] To prepare, add 1 g. of the dye to 100 c. c. of 5 per ct. phenol. This stain can be kept two or three months without deterioration. A drop of the stain should be placed upon the smear while the slide is still resting on the water bath, and allowed to remain for one minute. Enough stain should be used to prevent drying during the minute of heating. At the end of the minute wash the slide very briefly by immersion in water, without allowing it to stay in the water an appreciable length of time.[5]

After drying, examine under a microscope to see if the preparation is good. A good preparation should show the bacteria a deep pink or red, the mineral particles uncolored, some of the dead organic matter light pink but most of it either yellow or unstained. If the bacteria are faintly stained or if everything is stained pink,

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[4] Two other dyes of the phthalein series have been tested, namely eosine and phloxine. Neither gives permanent results. A 5 per ct. solution of phloxine in 5 per ct. phenol gives very good temporary results, altho the preparations fade rapidly. Good results have been obtained occasionally with eosine, but the technic is more difficult and the results less dependable.

[5] In the abstract of the previous paper on this subject (see footnote 3) a slightly different technic was mentioned. Two different staining methods were given, one of which called for rose Bengal or phloxine and differed from the above only in detail. Later work has shown the superiority of rose Bengal over phloxine and has shown the above technic to be an improvement over that previously given. The other method of staining (the fuchsin-methylen-blue method) has been found to give unsatisfactory results for research work. The preparations are very striking, however, for demonstration purposes, so perhaps the technic should be described. It is as follows:

To 40 c. c. water add 3 c. c. saturated alcoholic solution of methylen-blue and 0.8 c. c. saturated alcoholic fuchsin (each measured accurately). Immerse the slide bearing the dried soil infusion into this stain and allow it to remain from one to three minutes. Wash in water, dry and examine. The bacteria should be red, mineral particles blue, and organic matter blue to purple. The deeply stained soil particles so often obscure the bacteria that only a small portion of the total flora is visible, and if the method is used for demonstration purposes, recently manured soil or other soil with a rich bacterial flora should be used.

a new preparation should be made. The former condition generally indicates too long washing, the latter too great concentration of gelatin in the fixative or too old stain. Faint staining is especially troublesome, for it is almost sure to cause some of the bacteria to be overlooked. Whenever a count is suspiciously low and the bacteria do not stand out very plainly it is better to wash off the immersion oil in xylol and restain, or still better to make a new preparation, provided the trouble is discovered soon enough.

Microscopic examination.— These preparations should be examined with an oil-immersion objective and a high-power eye-piece. The combination of lenses found to be most satisfactory is a 1.9 mm. (1/12 inch) fluorite objective (having a numerical aperture of 1.32) with a 12.5× ocular. An Huygenian ocular of this magnification can be used; but with a compensating ocular it has been found possible to obtain a greater depth of focus. When counting bacteria it is advisable not to count the entire field, but to have the central portion of it marked off as described by Breed and Brew for milk work.[6] They used a disc in the eye-piece with circles and cross-lines ruled on it so as to limit the area within which the bacteria were counted. A similar arrangement may be used for soil, the size of the circle on the disc depending upon whether an Huygenian or compensating ocular is used. It has been found convenient to use a circle of such a size as to cover an area on the slide either 80 microns or 113 microns in diameter. Every organism in the former sized area represents approximately 2,000,000 per cubic centimeter of the soil infusion;[7] every organism in the latter 1,000,000 per c. c.

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[6] Page 26 of reference given in footnote 1.

[7] This is computed as follows:

Let r stand for radius of circle.

Then $r = \frac{80}{2}$ micron = 40 micron = 0.04 mm.

$r^2 = 0.0016$ sq. mm.

Area of circle $= \pi r^2 = 3.1416 \times 0.0016$ sq. mm. = 0.005027 sq. mm.

$$\frac{\text{Area of smear}}{\text{Area of cirle}} = \frac{1 \text{ sq. cm.}}{0.005027 \text{ sq. mm.}} = \frac{100 \text{ sq. mm.}}{0.005027 \text{ sq. mm.}}$$

= 19,900 or approximately 20,000.

Therefore each circle = approx. $\frac{1}{20,000}$ of entire smear.

But the smear contains only 0.01 c. c. of soil infusion.

Hence each circle contains approx. $\frac{1}{20,000} \times 0.01$ c. c.

$= \frac{1}{2,000,000}$ c. c. of soil infusion.

The computation for the larger size field is made in exactly the same way, in this case using the value:

r = 0.0565 mm.

(If soil has been diluted ten times, these factors should be multiplied by 10; i. e. 20,000,000 and 10,000,000 per gram of soil). It is possible to get the circle used to cover an area of either of these sizes by adjusting the length of the draw-tube; but it is better to use a circle of such a size as to give an even factor with the draw-tube down, as the most satisfactory results are obtained with a tube-length of 160 mm.[8]

It is important that a good source of illumination be used in this work. The brightest daylight can be used; but a better and more constant source of light can be obtained by artificial means. An electric light filtered thru "daylight" glass is very satisfactory; or a welsbach light filtered and condensed thru a blue globe containing ammoniacal copper sulphate. Minute organisms may easily be overlooked if the light is not good.

One word of caution is not out of place, altho to anyone experienced with a microscope it is unnecessary. As the smear of soil infusion is of too uneven thickness to allow the use of a coverglass, there is always danger that the objective will come into contact with the dried soil. Under such circumstances a slight motion of the slide might easily scratch the lens; so it is best to make it a rule never to move the slide unless the objective is at least far enough away from it to bring the objects in the smear into focus. With this reasonable care, no noticeable injury has been caused to an objective used extensively in this work for nearly two years.

LIMITATIONS OF THE METHOD.

In order to interpret correctly the results obtained it is necessary to recognize the limitations of the microscope in this work. These limitations may be considered under two heads: (1) those that apply in quantitative work alone, and (2) those that must be taken into account when using the method for qualitative purposes.

In quantitative work.— As already discussed there are certain limitations inherent in any microscopic method of counting bacteria. They are due to the difficulties in spreading the material evenly over the slide and in distinguishing the bacteria from other objects. Both of these difficulties are especially hard to overcome when the method is used for studying soil. Even distribution of the material is harder to accomplish for a solid like soil than for liquids like milk, blood or culture fluids. Also, the difficulty of distinguishing bacteria

[8] In the present work the circle on the disc in the ocular measured exactly 1 cm. in diameter. Used in connection with Bausch and Lomb 12.5× compensating ocular and 1.9 mm. objective this was found to cover an area of such a size as to give a factor of 1,000,000 per c. c. of soil infusion with the draw tube of the microscope down. As the slightest variation in the size of the circle would cause considerable variation in the size of the area included within it, the area should always be measured with the aid of a stage micrometer, even tho exactly this combination of lenses be used.

is increased in the case of soil, because of the abundance of tiny clay particles or fragments of organic matter that closely resemble bacteria.

The first of these difficulties — uneven distribution — may be partly overcome by examining a number of different smears from the same sample. It is impossible, however, to prevent bacteria from lying under soil particles or masses of organic matter; and such material generally obscures the bacteria because of its high refractive power even in well-stained preparations, in which it should be uncolored. Sometimes such a dense field is encountered that it has to be passed over; but in general, irregularities due to uneven distribution have not proved as great as might have been expected. Duplicate smears have shown a surprisingly good agreement in count.

The second limitation — difficulty in recognizing bacteria — is especially great in the case of soil, not only because of the many objects in soil that closely resemble bacteria, but also because of the minute size of many soil microörganisms. Such tiny bacteria are easily overlooked, and the constant fear of overlooking them sometimes induces the investigator to count all rod-shaped bodies, many of which are probably soil particles that owe their dark appearance not to the stain but to their high refractive power. Errors arising from this cause can be avoided only by training the eye to recognize the bacteria, and there is no way to determine how great the error is.

Under such circumstances accurate counts are not possible. The counts given in this bulletin must be understood as representing very rough estimates as to the actual number of bacteria present. The best use of the method is for qualitative rather than for quantitative purposes, that is, to show what kinds of microörganisms exist in soil in active form.

In qualitative work.— When using the method for qualitative purposes, these limitations are of less importance. In this work the chief difficulty arises from the fact it is impossible to tell one kind of bacteria from another and is sometimes hard to tell to what group of microörganisms a given individual belongs. The " conidia " of Actinomycetes, for instance, are so nearly like bacteria of the short rod type that much experience is required in order to decide which is which, and even a trained eye cannot tell them apart with any degree of confidence.

In brief, the chief limitation of the method in qualitative work is the fact that the organisms observed cannot be isolated and studied in pure culture. In an attempt to overcome this limitation in part, a study is being made of various soil organisms inoculated into sterilized soil in order to obtain familiarity with their appearance under such conditions. It is hoped that the experience thus gained may make the method of more use eventually for qualitative work than it is at present.

In spite of these limitations, much interesting information has already been secured by means of the technique. The following pages will show some of the results thus far obtained, and may perhaps suggest other uses to which it may be put in the future.

RESULTS OBTAINED.

Actual number of bacteria in soil.[9]—For a long time bacteriologists have been speculating as to the real number of bacteria in soil. It has been known that many soil bacteria are unable to grow on the culture media used in plating soil and that therefore the plate counts must be lower than the true number. The question has been whether the organisms not included in plate counts are of slight numerical importance or constitute a large part of the soil flora. Improvements in the plating technic have resulted in higher counts up to a certain limit; but there seems to be a point above which counts cannot be obtained by the plate method, whatever technic be used. The only method used in the past to check up plate counts of soil bacteria is the dilution method proposed by Hiltner and Störmer.[10] This method was used by Löhnis[11] in comparison with the plate method. Löhnis obtained higher counts by the dilution method, but no higher than are often obtained today by the plate method. In fact, Löhnis' plate counts are so low as to suggest that his plating technic was unsatisfactory. The dilution method, in short, has never been shown to give strikingly higher counts than the plate method. Hence the microscopic technic is the best method yet proposed for determining the actual number of bacteria in soil.

For the reasons above discussed, the microscope cannot answer this question with as much assurance as might be desired. It has been found possible, nevertheless, to obtain interesting information on the subject.

In Table I are listed eleven comparisons between the plate and microscopic counts of field soil. It will be seen that the microscopic counts are 10 to 70 times as great as the corresponding plate counts. If the microscopic counts actually represent the true number of bacteria, there are three ways of accounting for this great discrepancy: (1) Many of the bacteria may be dead; (2) the clumps

[9] The work reported in this section of the paper was done in collaboration with J. Bright. Mention of it has already been made in a paper presented at the 1917 meeting of the Society of American Bacteriologists, entitled: What is the actual number of bacteria in soil? J. Bright and H. J. Conn. (See the proceedings of the society in the February number of *Abstracts of Bacteriology*, Vol. 2.)

[10] Hiltner, L., and Störmer, K. Studien über die Bakterienflora des Ackerbodens, mit besonderer Berücksichtigung ihres Verhaltens nach einer Behandlung mit Schwefelkohlenstoff und nach Brache. *Kaiserl. Gesundheitsamte, Biol. Abt. Land- u. Forstw.*, 3:445–545. 1903.

[11] Löhnis, F. Zur Methodik der bakteriologischen Bodenuntersuchung II. *Centbl. Bakt.* Abt. II, 14:1–9. 1905.

or masses in which they occur may not break up when plated and hence may form but one colony each; (3) many of them may be species that do not grow on the media used in plating. Altho some dead bacteria are likely to be counted, the first of these explanations is unsatisfactory, Winslow and Wilcomb[12] having shown that dead bacteria, in the presence of live organisms, rapidly lose their staining power. The second explanation is shown to be unsatisfactory by the figures given in the next to the last column of Table I. The "group counts" listed in this column were obtained by counting each clump of individuals as well as each isolated individual as a unit. If every organism seen were capable of growing on the plates this "group count" should be the same as the plate count, or even somewhat lower because of the partial breaking up of the clumps

TABLE I.— NUMBER OF BACTERIA IN NORMAL FIELD SOIL.

(Figures indicate numbers per gram of soil.)

Date.	Soil.	Plate Count.		Microscopic Count.	
		Gelatin* colonies.	Agar* colonies.	"Groups."†	Individuals.
1917.					
May 15	Dunkirk silty clay loam. Cultivated	‡17,500,000	23,000,000	140,000,000	175,000,000
July 20	Dunkirk silty clay loam. Sod.....	14,000,000	17,000,000	218,000,000	340,000,000
July 20	Dunkirk silty clay loam. Cultivated	13,500,000	16,000,000	126,000,000	214,000,000
Aug. 10	Volusia silt loam. Sod...........	3,500,000	6,500,000	95,000,000	143,000,000
Aug. 10	Volusia silt loam. Cultivated......	3,800,000	8,500,000	97,000,000	144,000,000
Nov. 14	Ontario fine sandy loam. Sod....	13,500,000	18,000,000	248,000,000	390,000,000
Nov. 14	Ontario fine sandy loam. Cultivated	16,800,000	25,000,000	150,000,000	250,000,000
Nov. 21	Dunkirk silty clay loam. Cultivated	5,500,000	11,000,000	256,000,000	360,000,000
Nov. 21	Dunkirk silty clay loam. Cultivated	11,000,000	24,000,000	260,000,000	405,000,000
Nov. 23	Volusia silt loam. Sod...........	9,300,000	9,500,000	138,000,000	178,000,000
Nov. 23	Volusia silt loam. Cultivated......	5,800,000	5,000,000	174,000,000	230,000,000

* Asparaginate-glycerin agar and tap-water gelatin were used; see Tech. Bul. 57, p. 25.
† Every isolated individual, as well as each group of two or more, was counted as a "group."
‡ This gelatin count is inexact because of rapid liquefaction.

in the process of dilution preliminary to plating. As a matter of fact, however, the "group count" is from 8 to 45 times as large as the plate count. The average group is one of only about 1.5 individuals, as shown by dividing the figures in the last column of the table by those in the next to the last. Hence the second explanation is unsatisfactory. This leaves no explanation except that the majority of the soil bacteria do not grow on the plates. This is practically the same conclusion as reached by Winslow and Willcomb in regard to sewage; while on the contrary, Brew and Dotterrer[13] have found that in the case of milk the microscopic count is greater than the

[12] Winslow, C.-E. A., and Willcomb, G. E. Tests of a method for the direct microscopical enumeration of bacteria. *Jour. Inf. Dis.*, Suppl. 1:273–283. 1905.
[13] Brew, J. D., and Dotterrer, W. D. The number of bacteria in milk. N. Y. Agr. Exp. Sta. Bul. 439. 1917.

plate count, not so much because of organisms that do not grow, as because of clumps that do not entirely break up upon plating.

This explanation holds only on the assumption that the microscopic count is actually a count of bacteria and not one of mere specks that stain like bacteria. There are, however, so many tiny objects in soil closely resembling bacteria that there is always a doubt in the mind of the investigator whether he is actually counting microorganisms. Information in regard to this point has been obtained by correlating plate and microscopic counts. In Table I it will be noticed that the highest microscopic count (test No. 9) was made from the sample with the next to the highest agar count; and the two lowest microscopic counts (Nos. 4 and 5) from the samples with the two lowest gelatin counts. It is also to be noticed that there is a tendency for the microscopic counts of Volusia silt loam to be lower than those of the other soils — a fact which agrees not only with the plate counts listed in the table but also with other plate counts of these soils and with observations as to the rate of decomposition in Volusia silt loam, all of which indicate that this soil type is of low bacterial content. It is possible, however, to pick out so many individual cases in Table I where no such correlation exists that very little light can be obtained from it as to the meaning of the microscopic count.

Further information as to the significance of the microscopic count can be obtained from the experiment summarized in Table II. In this experiment 100 grams of horse manure were mixed with 2,000 grams of soil (Dunkirk silty clay loam) and kept in the laboratory in two pots. At frequent intervals, enough water was added to restore that lost by evaporation. Care was taken to see that the soil was brought to its original moisture content about twenty-four hours before any sample was taken, so that all the samples should represent comparable moisture conditions. One pot was sampled very frequently during the first two weeks of the experiment, the other only at longer intervals.

As in the case of field soil, the microscopic counts from these pots are much higher than the plate counts. The most interesting point, however, is that both plate and microscopic counts increased for about a week after adding the manure and then decreased with more or less regularity. The maximum plate count and maximum microscopic count both occurred on the same day, six days after adding the manure. Samples of Pot 2 were not taken often enough to follow the entire rise and fall of the bacteria, but the eight counts made show the same tendency.

This correlation between the two counts suggests very strongly that the microscopic count is actually an enumeration of the bacteria. A careful scrutiny, moreover, of those counts where there is no such correlation tends to indicate a superiority of the microscopic method. It will be noticed that the fifth, sixth and seventh microscopic counts of Pot 2 are lower than the corresponding counts of Pot 1, altho no

TABLE II.— NUMBER OF BACTERIA IN MANURED SOIL.
(Figures indicate numbers per gram of soil.)

TIME SINCE ADDING MANURE.	POT 1.				POT 2.			
	Plate count.		Microscopic count.		Plate count.		Microscopic count.	
	Gelatin* colonies.	Agar* colonies.	"Groups."†	Individuals.	Gelatin* colonies.	Agar* colonies.	"Groups."†	Individuals.
0 days	27,000,000	35,000,000	200,000,000	295,000,000	27,000,000	35,000,000	200,000,000	295,000,000
1 day	90,000,000	120,000,000	385,000,000	490,000,000	....	....	....	....
2 days	60,000,000	100,000,000	420,000,000	780,000,000	....	....	....	....
3 days	‡80,000,000	145,000,000	520,000,000	790,000,000	60,000,000	135,000,000	470,000,000	750,000,000
4 days	125,000,000	150,000,000	376,000,000	680,000,000	....	....	....	....
6 days	235,000,000	120,000,000	555,000,000	865,000,000	....	....	....	....
9 days	45,000,000	70,000,000	500,000,000	795,000,000	....	....	....	....
13 days	43,000,000	40,000,000	475,000,000	650,000,000	30,000,000	47,000,000	500,000,000	680,000,000
16 days	‡35,000,000	70,000,000	409,000,000	533,000,000	....	....	....	....
21 days	50,000,000	55,000,000	346,000,000	463,000,000	....	....	....	....
24 days	55,000,000	65,000,000	346,000,000	496,000,000	55,000,000	70,000,000	298,000,000	488,000,000
29 days	85,000,000	80,000,000	281,000,000	462,000,000	....	....	....	....
38 days	45,000,000	40,000,000	316,000,000	483,000,000	....	....	....	....
2 months	95,000,000	75,000,000	410,000,000	544,000,000	105,000,000	75,000,000	301,000,000	393,000,000
3 months	18,000,000	70,000,000	408,000,000	739,000,000	14,000,000	50,000,000	222,000,000	395,000,000
3½ months	....	42,000,000	286,000,000	500,000,000	....	46,000,000	161,000,000	291,000,000
4 months	20,000,000	23,000,000	190,000,000	445,000,000	28,000,000	45,000,000	244,000,000	506,000,000

* Asparaginate-glycerin agar and tap-water gelatin were used; see Tech. Bul. 57, p. 25.
† Every isolated individual, as well as each clump of two or more, was counted as a "group."
‡ These gelatin counts are inexact because of rapid liquefaction.

such difference is brought out by the plate method. The occurrence of this difference in three successive samples is enough to suggest that it is a real difference overlooked by the plate method. It will also be noticed that the plate count of both pots returns to its original level by the third month and the microscopic "group count" by the middle of the third month, while the microscopic count of individuals (except for the next to the last sample from Pot 2) does not reach its original level even by the fourth month. This indicates that in the manured soil some kind or kinds of organisms developed that formed clumps instead of breaking apart into isolated individuals and therefore did not affect the plate count. Similar evidence has been obtained from earlier work on manured soil which is not published in detail as it was done before perfecting the microscopic technic and the results are therefore inexact. Facts of this sort cannot be brought out by the plate method.

Further information as to the significance of the microscopic count can be obtained from the data given in Table III. In this experiment soil was placed in small Erlenmeyer flasks and sterilized two hours in an autoclave at fifteen pounds pressure, a treatment which not only killed the bacteria but disintegrated nearly all of them. Three pure cultures of common soil organisms were used for inoculating, one-third of the flasks being inoculated with each. At different lengths of time after inoculation, plate and microscopic counts were made as listed in the table. It will be noticed that the microscopic counts of *B. cereus* are always higher than the plate counts; but that the discrepancy between these two counts is much smaller than in the case of unsterilized soil. *B. cereus* is a large, easily visible organism that grows well on the plates, so fairly correct counts of it might be expected with either plate or microscope; and the relation between the two counts given in the table is much what might be anticipated. The other two organisms also grow well on bacteriological media, but they are both small bacteria, easily overlooked under the microscope. Accordingly, for both of these cultures, the plate count is considerably higher than the microscopic count — a relation the reverse of that which holds in unsterilized soil. These figures indicate that if an organism is present in soil that can grow well on the plates, the plate count will be nearly as high or even higher than the microscopic count. The logical conclusion is that the great difference between plate and microscopic counts observed in normal soil is due to organisms unable to grow on the plates.

In connection with this evidence from the pure cultures, however, one possibility must be recognized. Small particles of organic matter may be present in normal soil that take the stain and appear as bacteria under the microscope, but which lose their staining power when the soil is sterilized. If true, this might account for

the discrepancy between the two counts in normal soil which is not observed in the case of pure cultures; but it seems so unlikely that heating should affect the staining powers of dead organic matter, that no very great weight is attached to this possibility.

TABLE III.— NUMBER OF BACTERIA IN STERILIZED SOIL REINOCULATED WITH PURE CULTURES.

(Figures indicate numbers per gram of soil.)

DAYS SINCE INOCULATION.	PLATE COUNT.*	MICROSCOPIC COUNT.	
		"Groups."†	Individuals.
Culture No. 1 (*B. cereus*).			
TEST No. 1.			
3 days	3,000,000	5,000,000	9,000,000
5 days	1,750,000	6,000,000	6,000,000
7 days	15,000,000	36,000,000	50,000,000
TEST No. 2.			
2 days	4,000,000	20,000,000	46,000,000
4 days	5,000,000	14,000,000	27,000,000
8 days	10,500,000	18,500,000	35,000,000
10 days	10,000,000	17,000,000	25,000,000
Culture No. 2 (*Ps. fluorescens*).			
TEST No. 1.			
3 days	260,000,000	197,000,000	204,000,000
5 days	185,000,000	133,000,000	152,000,000
7 days	475,000,000	259,000,000	325,000,000
TEST No. 2.			
2 days	140,000,000	79,000,000	88,000,000
4 days	260,000,000	173,000,000	188,000,000
8 days	315,000,000	236,000,000	247,000,000
10 days	350,000,000	310,000,000	328,000,000
Culture No. 3. (Orange liquefying type. See Tech. Bul. 59, p. 8.)			
TEST No. 1.			
3 days	665,000,000	492,000,000	608,000,000
5 days	4,800,000,000	1,340,000,000	1,615,000,000
7 days	1,720,000,000	1,105,000,000	1,254,000,000
TEST No. 2.			
2 days	1,050,000,000	728,000,000	728,000,000
4 days	1,350,000,000	760,000,000	784,000,000
8 days	1,460,000,000	736,000,000	800,000,000
10 days	1,200,000,000	795,000,000	822,000,000

* Tap-water gelatin was used; see Tech. Bul. 57, p. 25.

† Every isolated individual, as well as each group of two or more, was counted as a "group."

Summing up, it may be said that altho none of these lines of evidence furnishes conclusive proof, they all tend to indicate that the microscopic count is an actual count of the living microörganisms in soil. Such being the case, it is plain that there are many more of the soil bacteria than of the milk bacteria that do not grow on the plates — just how many it is impossible to state. Probably the actual number of bacteria in soil is five, ten, or even twenty times greater than indicated by the plate count.

Spore-forming bacteria in soil.— Aside from the quantitative results, other findings of value have resulted from the work. Of special interest are those relating to the spore-forming bacteria. In previous papers [14] the significance of this group of bacteria has been discussed, and it has been shown that in spite of former ideas as to their importance, no conclusive evidence as to their activity in normal soil has yet been obtained. This conclusion was reached by means of cultural studies, unsupported by a microscopic investigation; but as soon as the microscopic technic was perfected, it was used to throw additional light on this same question.

The spore-forming bacteria are as a rule quite large, the three forms isolated most abundantly from soil (*B. megatherium* De Bary, *B. cereus* Frankland and *B. mycoides* Flügge) all having a diameter of one micron or over. They are, in fact, almost if not absolutely the only large rods that can be obtained from soil by means of culture plates. When a culture of one of these organisms is mixed with soil, its vegetative rods and spores both show very plainly under the microscope. In fact Table III shows that microscopic counts of *B. cereus* in soil were higher than the corresponding plate counts. This indicates that spore-forming bacteria could hardly have been overlooked in the soils studied by means of the microscope, and the results therefore have considerable significance.

The results are given in Table IV. In the first column of figures are listed the numbers of small rods observed (ordinarily under 0.5 micron in diameter). These counts probably include as many Actinomyces conidia as true bacteria; but the two are not listed separately because of the difficulty in distinguishing between them in all cases. The next column contains the numbers of medium-sized rods observed (about 0.5–0.8 micron in diameter). This is about the size of *Ps. fluorescens* (Flügge) Migula, and is much smaller than such forms as *B. cereus*. An occasional spore-former— *B. mesentericus* (Flügge) Migula, for instance — may be as small as this; but as these small spore-formers have rarely been isolated from soil, these figures are probably counts of non-spore-forming bacteria. The last column lists the number of spores observed.

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[14] Conn, H. J. Are spore-forming bacteria of any significance in soil under normal conditions? N. Y. Agr. Exp. Sta., Tech. Bul. 51. 1916. *Jour. Bact.*, 1:187–195. 1916.

Conn, H. J. Spore-forming bacteria in soil. N. Y. Agr. Exp. Sta., Tech. Bul. 58. 1917.

In making these counts of spores, every object bearing any resemblance to a spore was counted, even tho it was suspected to be something entirely different; nevertheless the number of spores recorded was only about 1 per ct. of the total flora observed. Large rods (1 micron or more in diameter) such as those of *B. cereus*, *B. megatherium* or *B. mycoides*, were not found at all in the samples. It seems reasonable, therefore, to conclude that the large spore-formers were not active in these soils, that the small spore-formers probably were not active; but, if so, certainly comprised but a very small percentage of the total bacterial flora. This entirely corroborates the previous conclusions derived from cultural studies alone.

TABLE IV.— CLASSIFICATION BY MEANS OF THE MICROSCOPE OF THE BACTERIA IN NORMAL FIELD SOIL.

Date.	Soil.	Bacteria per Gram, Determined Microscopically.		
		Small rods.	Medium-sized rods.	Spores.
1917.				
May 15	Dunkirk silty clay loam. Cultivated....	167,000,000	3,000,000	5,000,000
July 20	Dunkirk silty clay loam. Sod..........	334,000,000	3,000,000	3,000,000
July 20	Dunkirk silty clay loam. Cultivated....	206,000,000	4,000,000	4,000,000
Aug. 10	Volusia silt loam. Sod................	141,000,000	1,500,000	500,000
Aug. 10	Volusia silt loam. Cultivated..........	140,000,000	3,500,000	1,000,000
Nov. 14	Ontario fine sandy loam. Sod..........	375,000,000	12,000,000	3,000,000
Nov. 14	Ontario fine sandy loam. Cultivated....	245,000,000	3,000,000	3,000,000
Nov. 21	Dunkirk silty clay loam. Cultivated....	350,000,000	8,000,000	3,000,000
Nov. 21	Dunkirk silty clay loam. Cultivated....	390,000,000	7,000,000	6,000,000
Nov. 23	Volusia silt loam. Sod................	172,000,000	4,000,000	2,000,000
Nov. 23	Volusia silt loam. Cultivated..........	228,000,000	1,500,000	750,000

Absence of mold hyphae.— One of the most surprising results so far obtained is to find that mold hyphae occur so seldom in the soils studied that for all practical purposes they may be considered absent. Attention has already been called to this point.[15] They are not only too rare to be included in any of the counts given above, but actually occur so seldom in many soils that hundreds of microscopic fields can be examined without finding a single fragment of mycelium. There is, of course, no question but that fungi can live in soil; and such an unexpected finding gave rise to the suspicion that fungi might assume some unfamiliar form when growing in soil and might therefore escape recognition. To check up this point, some woodland soil, with more or less leaf mold on the surface, was examined by the usual technic. In this preparation mold hyphae were found, not by any means as abundantly as the bacteria but rather more so than Actinomyces filaments. This shows quite plainly that the technic is capable of revealing fungus mycelium

[15] Conn, H. J. Relative importance of fungi and bacteria in soil. *Sci.*, N. S., 44:857-858. 1916.

when present; and the failure to find it in any microscopic preparation presumably means that fungus growth is not sufficiently abundant in that particular soil to show under the microscope.

Considering that Waksman[16] has recently reported finding considerable numbers of fungi in soils obtained from all parts of the country, it seemed surprising, at first thought, that they were not abundant enough in any of the agricultural soils studied to be revealed by the microscope. It was found, however, by microscopic examination of a colony of Aspergillus growing on an agar plate, that this colony bore spores enough to give a plate count of 300,000 per gram (about the average plate count of fungi found by Waksman) provided it were distributed evenly thruout a kilo of soil and every spore were capable of growth on culture plates; and yet such a small amount of mycelium would be added to the soil that only one fragment of mold hyphae would be found in every 3,000 microscopic fields, using the dilution and magnification employed in the present work. This suggests that if a fungus capable of producing spores in the soil were abundant enough to show mycelium under the microscope, its plate count would be enormous. It shows further that a soil might have a plate count of fungi as high as reported by Waksman without showing mycelium under the microscope. In other words, there is no real inconsistency between the present findings and those of Waksman.

If in comparing Waksman's conclusions with the results of the present investigation, the question arises as to whether the plate count or the microscopic study has the greater significance, there can be but one answer. It must be admitted that plate counts of organisms like Actinomycetes and higher fungi do not have the same significance that plate counts of bacteria do. If in the kilo of hypothetical soil above mentioned just ten spores should germinate and produce colonies bearing as many spores as the original colony, the plate count would become 3,300,000 per gram without any very great fungus activity taking place. Suppose, on the other hand, this mold were not capable of spore-production in soil. Then it might grow vigorously and profoundly modify the character of the soil while the plate count, which would still indicate the number of spores, would probably diminish. Obviously the plate count of a fungus indicates, not numbers of individuals, but ability to produce spores.

It should further be pointed out that the species of fungi found most abundantly by Waksman (Mucorales, Aspergilli, Penicillia, etc.) are common dust fungi; and their general occurrence, therefore, in soils from different parts of North America and Europe does not prove that soil has a characteristic fungus flora. On the other hand, it is not claimed that the failure to find fungi in microscopic

[16] Waksman, S. A. Is there any fungus flora of the soil? *Soil Sci.*, 3:565–589. 1917.

preparations disproves their activity in agricultural soils in general. The matter is discussed here in order to explain the apparent inconsistency between the results obtained by the plate method and those by the microscopic method; and to emphasize need of caution in interpreting the plate count of a spore-forming organism.

Actinomycetes in soil.— In an earlier paper [17] the question was raised whether Actinomycetes occur in soil as filaments or as "conidia." The microscope has partly answered this question. Both forms occur. The "conidia," however, are so much more numerous than the filaments that there is no question but that practically all the colonies of Actinomycetes on the plates arise from spores. Just as in the case of higher fungi, the plate count is not an index of activity but of ability to produce spores. The use of the microscope is necessary to interpret the plate count. Microscopic examination shows the great preponderance of spores over filaments and proves that a very high plate count of Actinomycetes does not necessarily indicate more than a slight activity of these organisms. Their filaments, however, are not lacking in any soil yet studied; and occasionally large colonies have been found, containing both filaments and conidia. Altho such masses of actively growing Actinomycetes are quite rare compared to the numbers of true bacteria observed, they are much more common in ordinary soil than are the hyphae of higher fungi. This indicates that Actinomycetes are comparatively active in soil, altho they are probably not as important as the plate count would suggest.

Arrangement of the soil bacteria.— Plate cultures give no idea whether the colonies arise from single organisms or from clumps containing thousands. Brew and Dotterrer [18] have already shown that the average clump of bacteria in market milk contains between eight and eleven individuals; but in the soils so far studied the clumps of bacteria are much smaller. A great majority of the soil bacteria occur singly. A striking exception is a certain small short rod found quite abundantly in some samples of the surface crust of soil. This rod occurs in large sheets one individual thick, but sometimes containing thousands of individuals. The rods are arranged in rows, curved or straight, that form beautiful patterns. Sometimes they have been observed forming sheets around mineral particles; and at other times they have been found in hollow masses, irregularly spherical and always somewhat torn, which there is good reason to believe were originally formed around mineral particles, the soil particle having been forced out during the process of making the smear. The identity of this organism is still unknown; and it may be important in soil, altho it is not likely to occur to a large extent upon plates made from soil.

[17] Conn, H. J. Actinomycetes in Soil. N. Y. Agr. Exp. Sta., Tech. Bul. 60. 1917.
[18] See footnote 11.

The size of the average group of bacteria in soil is important in interpreting the plate count. As the bacteria ordinarily occur singly or in small groups, the plate count is probably a fairly accurate count of those bacteria capable of growing on the plates. The discrepancies between plate and microscopic counts are due not to the breaking up of clumps but to the inability of many of the organisms to grow on the plates.

CONCLUSIONS.

As a result of this study, the conclusion seems justified that the microscope offers very promising possibilities for the study of bacteria and fungi in soil. Alone it does not yield results of as great value as when used in conjunction with cultural methods; but in connection with them it can furnish direct evidence in regard to many obscure points. Its principal uses seem to be to determine the number of bacteria in soil that do not grow on culture plates, and to learn whether an organism with spores or resting-stage is active or inactive in any particular soil. The data along these lines presented in the present bulletin are not very extensive, but it is hoped that they will suggest to other workers further uses to which the method may be put.

MILKING MACHINES.*

MAY BE OF GREAT SERVICE DURING THE PRESENT LABOR SHORTAGE IF USED ON FARMS WHERE 20 OR MORE COWS ARE KEPT.

SELECTING A MACHINE.

Use the same business judgment that you would in buying other machines. If irresponsible agents tell you the same stories that they have told to us, many of them should be accepted with a grain of salt. The longer a machine has been in successful operation, the surer you can be that it is a mechanical success. A record of three years of successful operation is none too long to make sure that a machine is worth buying, and the record should have been made independently of the manufacturer.

Do not accept statements that machines which allow stable air to pass into the machine with the milk are failures because they are unsanitary. Our recent tests show that only insignificant numbers of bacteria are added to the milk in this way.

OPERATING A MACHINE.

Even if you have installed a machine which is as good as there is to be had, you may be sure it will not be a success on your farm unless you operate it properly. It is as necessary to use judgment and care in milking a cow by machine as by hand. The cow is not a machine and never can be made over into one. If you fail to make a success of a machine which others have used successfully for three or more years, the probabilities are that the trouble is with you. Instead of getting discouraged study the machine and try to discover what is wrong. We should be glad to pass on to you any information of value which we have gained from our ten years of experience with machine milking.

CAN YOU GET AS MUCH MILK BY MACHINE AS BY HAND?

Yes. Bulletin 353 answers this question. The records there given are by far the most extensive that have ever been gathered.

KEEPING THE MACHINE BACTERIOLOGICALLY CLEAN.

This is just as important as operating it properly. Very few farmers who are using machine milkers are keeping them bac-

* Reprint of Circular No. 54 (Revised) November 1, 1918.

teriologically clean. Where this is not done, the milk usually has a germ content of 50 to 10,000 per c. c. as it enters the teat cups and leaves them with a germ content of 200,000 to 5,000,000 per c. c. Such milk spoils quickly and is not fit to be sold as market milk, or for butter or cheese making.

The pail can be kept clean in the same way that any milk pail is kept clean. *Steam or scald it and dry it out thoroly.*

The rubber parts cannot be kept free from bacteria by ordinary methods of cleaning. The moisture and traces of milk left in the tubes present conditions so favorable to the growth of bacteria that only a few hours suffice to develop them in enormous numbers. The bacteria are only partially dislodged by drawing water thru the tubes, even where the water is boiling hot. They are continually loosened from the surface of the tubes during milking, only slowly diminishing in numbers during the milking of successive cows.

Various solutions are now recommended in which the teat-cups and tubes may be immersed between milkings. These prevent the development of the bacteria and may kill the bacteria already present if the tubes are reasonably clean. This makes it possible to draw milk by machine which is both cleaner, and freer from bacteria than is hand drawn milk. However, in our experience, we have not found one farmer in ten who took sufficient care to keep his machine bacteriologically clean. Even those dairymen who are inclined to keep their dairy utensils in good condition find it difficult to clean the machines because of the lack of adequate facilities for heating water, and for cleaning the machines at the milk house.

PREPARATION OF THE SOLUTIONS IN WHICH TO KEEP THE TUBES.

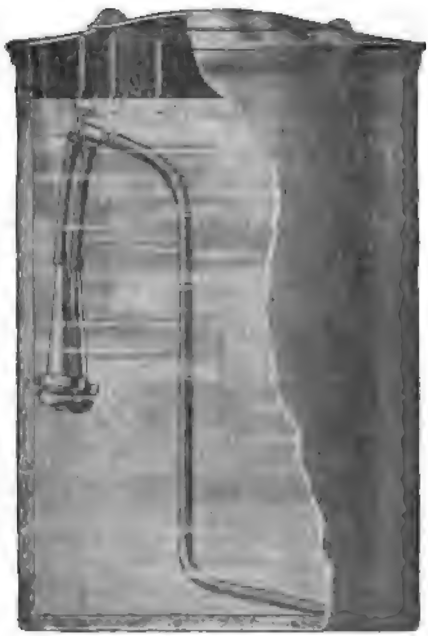
Thus far we have found only three solutions which we regard as satisfactory for use and none of these are entirely satisfactory under all conditions. They are (1) a mixture of brine and chloride of lime, (2) lime water to which chloride of lime may be added, and (3) cold running water. The values of these have been compared in our own stable under practical conditions (see Bulletin 450).

1. *Brine and chloride of lime.* The solution which has proved the cheapest and most successful with our B-L-K machines is prepared as follows:

Chloride of lime (bleaching powder, chlorinated lime, calcium hypochlorite) is purchased at a drug store in 12 oz. cans, care being taking to make sure that no rusted cans nor lumpy, moist powder are secured, and that the druggist has not kept the material in stock for weeks. A single can of this is added to a gallon of water in a large pitcher or covered crock and is stirred thoroly. After standing for a few hours, the white powder settles leaving a clear, greenish colored liquid. This solution is kept as a stock solution.

Commercial sodium or calcium hypochlorite solutions such as Bacilli-Kil, Hypozone, Germ-Kil, O. K. Sterilizer and the like may be used in place of this stock solution; but they are much more expensive and no better for the purpose than the solution just described and should ordinarily be used in stronger solutions than recommended on their labels. They should never be used without adding salt as recommended here.

The tubes are kept in a large covered 30-gallon crock (See figure) which is filled with clean water. Sufficient salt is added to the water



STERILIZING SOLUTION CROCK.

to make a strong brine (40 to 50 lbs.). At least a pint of the stock solution of chloride of lime is added to this jar twice a week, the latter being necessary in order to keep the brine sterile. The salt in the solution is necessary because all hypochlorite solutions lose their strength rapidly and either thru carelessness or hot weather may be and are frequently used up so rapidly that the solutions become foul, ill smelling and worse than useless.

The brine and chloride of lime solution may be used indefinitely if kept covered and clean, and enough water and salt are added to make up for wastage.

This solution was found to keep our tubes practically sterile when they were cleaned as described below. Dairymen using other types of machines in which iron parts are present may have trouble from rusting. Care must be taken where double lined teat-cups are used to keep the brine out of the air line as this causes rusting of the pipes and may cause a heavy expense for repairs. Convenient covers for the crocks can be easily made of wood, or iron covers may be purchased from some manufacturers of milking machines. Brass hooks reaching well down into the jar are a convenient way of supporting the tubes.

2. *Lime water*. The above solution is not a good one to use where injury may be caused by rusting, or where the metals used in the teat-cups are corroded by hypochlorites. A solution frequently used under such conditions and which our analyses show to be satisfactory is ordinary lime water prepared from unslaked lime.

The solution is prepared by placing 5 to 10 pounds of unslaked lime in the bottom of a 30-gallon crock, slaking the lime carefully and then filling the jar with clean water. If the white deposit in the bottom of the jar is stirred occasionally this solution may be used for six months or more. Care should be taken to protect the jar from dirt by covering, and a new solution should be made in case dirt gets into the jar.

This solution may be improved by adding hypochlorites (either calcium or sodium hypochlorite) as in the case of the brine.

3. *Running cold water*. Excellent bacteriological results were secured in our dairy where the tubes were placed in a 30-gallon crock thru which a stream of cold water was continually passing at a rate of about 12 gallons an hour. However as soon as the water became warmer than 60° F. during the summer months, the bacteria multiplied rapidly in the tubes and large numbers of them passed over into the milk during milking. An excellent practice is to so arrange the tubes that the stream of water passes directly thru them.

Stagnant water or water warmer than 60° F. will not give satisfactory results.

PROCEDURE FOR CLEANING MACHINES.

None of the solutions recommended will injure the rubber tubes. Likewise not one of them will keep the tubes free from bacteria unless the tubes are kept clean. Therefore if satisfactory milk is to be produced, proper facilities should be provided for cleaning the pails and tubes and attention given to following directions as given here.

Immediately after each milking prepare three pails. Fill pail 1, with clean cold water, pail 2 with hot soda water, and pail 3 with clean hot water. While the teat cups are still attached to the machine immerse them in these pails successively, at the same time sucking

the water thru them. Then take the teat cups and stanchion hose and either suspend them or immerse them in the solution in the large crock. Care should be taken when putting the tubes into the solution to make sure that all air bubbles are out of the tubes and that they are completely immersed.

Once a week the rubber teat cups should be taken apart completely and each part thoroly cleaned. *No disinfecting solution will take the place of cleaning.*

Just before beginning to milk, suck a pail of clean water, preferably hot, thru all of the teat cups. Otherwise traces of the disinfectants may be carried over into the milk. However, even if traces are carried over, harmless compounds are formed in the case of all of the solutions recommended.

DO MILKING MACHINES SPREAD OR CAUSE GARGET?

It is frequently claimed that they do, but there is no satisfactory evidence upon which to base such a claim. Thus far very few records have been secured upon which to base an intelligent opinion. We have had no more trouble with garget in the Station herd in the case of machine-milked cows than in the case of hand-milked cows. Moreover, such records as we have been able to gather in the course of milk control work where we examined the milk from 36–40 farms (eight of which have used or are using machines of four different makes) do not indicate that garget is spread any worse in the machine-milked than in the hand-milked herds. In the course of two years four herds have been badly affected with garget. Two of these were hand milked, two machine milked. Machine milking was discontinued on one farm partly on account of the garget. On the other farm machine milking was continued and the garget infection cleared up fully as quickly as it did on the farms where hand milking was practiced: Further information secured under carefully controlled conditions must be obtained before it will be clear whether or not this claim that garget is spread by machine milking is true. There is no evident reason why it should be so.

FINAL WARNING.

The labor shortage has caused and will cause machines to be put upon the market which are intended to sell rather than to give satisfaction. Deal only with responsible firms whose business reputation is worth more to them than the few thousand dollars which can be gained by selling milking machines.

THE STANDARDIZATION OF MARKET MILK.*

DR. L. L. VAN SLYKE.

The standardization of market milk is attracting much attention at the present time. Very little information is available in regard to it. This article has for its purpose a discussion of this subject with a view to furnishing some desirable facts. The treatment is intended to be suggestive rather than exhaustive.

What do we mean by the standardization of milk? Or, perhaps, it is better to put the question in this form: "What do we mean by standardized milk?" We get no help from the dictionary. What kind of a standard have we in mind? Is it a sanitary standard, covering the number of bacteria in milk, the amount of dirt, acidity, and the like? Is it a standard of composition based on fat and solids? Is it something else?

It becomes obvious at once that the expression "standardized milk." does not carry its meaning on its face. As a matter of fact there is no generally recognized, authentic definition. Our chief interest in this connection is some sort of a reasonable statement which applies to conditions in New York State and which can be utilized as a basis for our discussion.

Another expression is in common use, synonymous with standardized milk, and that is "adjusted milk." It is therefore desirable to incorporate these two terms in our definition.

The following statement is offered as a definition of the kind of milk that forms the subject of our discussion:

"*Standardized milk or adjusted milk is milk in which the original fat content has been changed, and also the ratio of fat to the other milk solids, by the removal of milk-fat, or by the addition of skim-milk, or by the addition of cream.*"

Of course, when it comes to legalizing the sale of standardized or adjusted milk, then we have to consider the application of this definition under conditions of specific limitations and regulations, as will be pointed out later in some detail.

We will now consider the subject in the following relations:

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*Reprint of Circular No. 56, January 1, 1918, which is an address delivered by Dr. Van Slyke at New York State Dairymen's meeting, Syracuse, New York, December 13, 1917.

(1) Effect of standardizing or adjusting milk upon the composition of normal milk.

(2) Relations of standardized or adjusted milk to producers, distributors and consumers.

(3) Advantages and objections.

(4) Legal regulations relating to the production and sale of standardized or adjusted milk.

I — EFFECT OF STANDARDIZING MILK UPON ITS COMPOSITION.

The fat content of milk can be changed, with a change of ratio of fat to other solids, either by decreasing or by increasing the percentage of milk-fat. In either case we have a standardized or adjusted product.

We will first consider the case in which we have a reduction of milk-fat. The percentage of fat in milk can be decreased, with change of ratio of fat to other solids, either by removal of fat or by addition of skim-milk. This is ordinarily accomplished in practice by separating a portion of the milk and then adding the skim-milk thus obtained to the remaining whole milk. Just how the reduction of the percentage of fat is accomplished is, however, immaterial for our present purpose. What we want to know now is the effect of such reduction upon the composition of normal milk.

When we remove cream from milk, the chief solid constituent that we take out is milk-fat. It is true that we also take out small amounts of other solids, which we commonly speak of as solids-not-fat, these including sugar, casein, albumin and salts of milk. But, for all practical purposes, in studying the effect of removal of fat on composition of milk, we are justified in saying that only fat is removed. Therefore, when we take cream from milk, we reduce the percentage of fat in the milk but not appreciably the percentage of the other solids, the solids-not-fat.

We can readily make these statements clear by a few illustrations. The figures given are sufficiently accurate for our purpose and for all practical purposes.

We will start with normal milk containing 4 per ct. of milk-fat and 9.1 per ct. of solids-not-fat. When we take 100 pounds of such milk and remove 1 per ct. of fat, that is, 1 pound of fat, it is obvious that we have 3 pounds, or about 3 per ct. of fat left in the milk. How about the solids-not-fat? We have essentially the same amount as in the normal milk before removal of fat, that is, about 9.1 per ct. We can bring out somewhat more clearly what happens by comparing this standardized or adjusted milk, made to contain 3 per ct. of fat, with the composition of normal milk containing 3 and 4 per ct. of fat.

COMPOSITION OF NORMAL AND "STANDARDISED OR "ADJUSTED" MILK.

(Changed by removal of cream.)

	Per ct. of fat.	Per ct of solids-not-fat.	Ratio of fat to solids-not-fat.
Normal milk containing....................	3	8.60	1 : 2.87
Normal milk containing....................	4	9.10	1 : 2.27
Adjusted milk containing..................	3	9.10	1 : 3.03

These figures show clearly that in milk standardized or adjusted to contain 3 per ct. of fat, made from normal milk containing 4 per ct. of fat, we have the same amount of fat as in normal milk containing 3 per ct. of fat, but we have the 9.1 per ct. of solids-not-fat contained in normal milk carrying 4 per ct. of fat. Normal milk containing 3 per ct. of fat contains an average of about 8.60 per ct. of solids-not-fat, while standardized or adjusted milk containing 3 per ct. of fat and made from normal milk containing 4 per ct. of fat, contains 9.1 per ct. of solids-not-fat. In other words, such a standardized or adjusted 3 per ct. fat milk contains per 100 pounds one-half pound more of solids-not-fat than does normal 3 per ct. fat milk.

In the last column of the table above, we have the amount of solids-not-fat for each pound of fat in milk in the different milks. It is obvious that the removal of fat changes very noticeably the ratio or proportion of fat to solids-not-fat, raising it from 2.27 in normal 4 per ct. fat milk to 3.03 in the adjusted or standardized 3 per ct. fat milk.

Similar results, only more striking, are shown when normal milk containing 5 per ct. of fat is adjusted or standardized to contain 3 per ct. of fat. We have the results shown by the following figures:

COMPOSITION OF NORMAL AND "STANDARDISED" OR "ADJUSTED" MILK

(Changed by removal of cream.)

	Per ct. of fat.	Per ct. of solids-not-fat.	Ratio of fat to solids-not-fat.
Normal milk containing....................	3	8.60	1 : 2.87
Normal milk containing....................	5	9.50	1 : 1.90
Standardized milk containing..............	3	9.50	1 : 3.17

In this case the standardized or adjusted 3 per ct. fat milk, made from normal 5 per ct. fat milk, contains the solids-not-fat belonging to normal 5 per ct. fat milk, that is, about 0.9 pound more per 100 pounds than in normal 3 per ct. fat milk. The ratio of fat to solids-not-fat in the adjusted milk is 1:3.17, which is much higher than in normal 3 per ct. fat milk.

We will give one more illustration, showing the results of adjusting normal 5 per ct. fat milk to standardized milk containing 4 per ct. of fat.

COMPOSITION OF NORMAL AND "STANDARDIZED" OR "ADJUSTED" MILK.

(Changed by removal of cream.)

	Per ct. of fat.	Per ct. of solids-not-fat.	Ratio of fat to solids-not-fat.
Normal milk containing....................	4	9.10	1 : 2.27
Normal milk containing....................	5	9.50	1 : 1.90
Adjusted milk containing..................	4	9.50	1 : 2.37

In this case the adjusted milk contains 4 per ct. of fat but it contains the amount of solids-not-fat belonging to normal milk containing 5 per ct. of fat.

The figures furnished by the three preceding illustrations all go to show that *when the percentage of fat in milk is reduced, the resulting standardized or adjusted milk contains the percentage of solids-not-fat in the original normal milk.* Therefore, the food value of the adjusted milk is somewhat greater than that of normal milk containing the same percentage of fat as that to which the richer milk has been reduced. Standardized or adjusted milk containing 3 per ct. of fat and made from richer milk is richer in solids-not-fat than normal milk containing 3 per ct. of fat. Standardized or adjusted milk containing 4 per ct. of fat and made from richer milk is richer in solids-not-fat than is normal milk containing 4 per ct. of fat.

Next, let us see what happens to the composition of milk when it is standardized or adjusted by the reverse process, that is, by the addition, instead of removal, of cream. Briefly answered, such standardized milk contains obviously more fat than the original milk, but it contains essentially the same percentage of solids-not-fat as the original milk. Such adjusted or standardized milk contains a smaller percentage of solids-not-fat than does normal milk containing the same percentage of fat.

We will illustrate these statements first by seeing what happens when we add enough cream to normal 3 per ct. fat milk to make it into an adjusted milk containing 4 per ct. of fat.

COMPOSITION OF NORMAL AND "STANDARDIZED" OR "ADJUSTED" MILK.

(Changed by addition of cream.)

	Per ct. of fat.	Per ct. of solids-not-fat.	Ratio of fat to solids-not-fat.
Normal milk containing....................	3	8.60	1 : 2.87
Normal milk containing....................	4	9.10	1 : 2.27
Adjusted milk containing..................	4	8.60	1 : 2.15

Here, in the case of the normal 3 per ct. fat milk, made into standardized 4 per ct. fat milk, we see that, while the fat increases to 4 per ct., the solids-not-fat remain at 8.60 per ct. just as in the normal 3 per ct. fat milk. The adjusted milk contains the fat of 4 per ct. milk but the solids-not-fat of normal 3 per ct. fat milk. Such standardized milk has less food value by one-half pound of solids-not-fat per 100 pounds of milk than is contained in normal milk containing 4 per ct. of fat. The ratio of fat to solids-not-fat is reduced from 2.27 to 2.15 for 4 per ct. fat milk, normal and standardized.

Let us take one more illustration, adjusting normal 3 per ct. fat milk to standardized milk containing 5 per ct. of fat.

COMPOSITION OF NORMAL AND "STANDARDIZED" OR "ADJUSTED" MILK.

(Changed by addition of cream)

	Per ct. of fat.	Per ct. of solids-not-fat.	Ratio of fat to solids-not-fat.
Normal milk containing....................	3	8.60	1 : 2.87
Normal milk containing....................	5	9.50	1 : 1.90
Standardized milk containing................	5	8.60	1 : 1.72

We have here in more exaggerated form results similar to those obtained in the preceding illustration. The adjusted milk contains 5 per ct. of fat, but only 8.60 per ct. of solids-not-fat instead of 9.50 per ct. of solids-not-fat, which is the amount that normally goes with milk containing 5 per ct. of fat. The ratio of fat to solids-not-fat drops from 1.90 in the normal milk to 1.72 in the standardized milk.

Summarizing the results which have been presented in showing the effect of standardizing or adjusting milk upon the composition, we have seen:

(1st.) When we decrease the percentage of fat in normal milk by removal of cream or by addition of skim-milk, we readjust not only the percentage of fat but particularly the ratio or proportion of fat to the other milk solids. This readjustment has the effect, it may be said, of standardizing or adjusting the solids-not-fat *up* in relation to fat.

(2nd.) When we increase the percentage of fat in normal milk by the addition of cream, we readjust the ratio or proportion of fat to solids-not-fat in such a way that we standardize or adjust the solids-not-fat *down* in relation to fat.

(3rd.) When we standardize or adjust milk by reducing the percentage of fat, we increase somewhat the food value of the milk in solids-not-fat in comparison with normal milk containing the same percentage of fat as the standardized or adjusted milk. Thus, for example, standardized 3 per ct. fat milk, made from 4 per ct.

fat milk, has somewhat more food value in solids-not-fat than has normal 3 per ct. fat milk.

(4th.) When we adjust or standardize milk by addition of cream, we decrease somewhat the food value of the milk in solids-not-fat in comparison with normal milk containing the same percentage of fat as the adjusted or standardized milk. Thus, for example, standardized or adjusted 4 per ct. fat milk, made by adding cream to 3 per ct. fat milk, has somewhat less food value in solids-not-fat than has normal 4 per ct. fat milk.

II. RELATIONS OF STANDARDIZATION OF MILK TO PRODUCERS, DISTRIBUTORS AND CONSUMERS.

Producers who sell milk to distributors may have little or no interest in the standardization of milk. However, it is probable that some questions now unforeseen might develop, affecting the interests of such producers. Those producers who sell milk directly to consumers might find it to their advantage to standardize their milk, especially when their herds may produce milk below the minimum legal standard. It would also be of advantage when milk of fairly uniform fat content is desired by one's customers. It is probable, however, that standardization would be made use of by producers only in exceptional instances.

The desire to introduce the practice of standardizing or adjusting milk comes mainly from distributors who handle large amounts of milk gathered from an extended territory for the purpose of supplying cities. The milk which they purchase from individual producers varies more or less widely in composition, especially in percentage of fat. Under present methods of mixing milk in a haphazard way, the milk distributed to consumers varies more or less in composition. If standardization is permitted, a product of much greater uniformity in percentage of fat can be furnished. Further, in case at any time a large amount of normal milk should drop below the minimum legal standard of 3 per ct. of fat, the milk before distribution can easily be brought above such standard by adjusting. Again, dealers who desire to furnish regularly to customers milk above a definite guaranteed percentage of fat can do so more conveniently by means of standardization than is possible under present conditions.

In relation to consumers, standardization of milk is a matter of practical interest. It would be practicable for them to obtain milk of a more uniform composition and also of any definite composition in milk-fat, whether 3, 4, 5 or other percentage were desired.

The statements indicate some of the more obvious and important relations that standardization of milk bears to the three parties interested.

III.— ADVANTAGES AND OBJECTIONS IN RELATION TO STANDARDIZATION OF MILK.

The more obvious advantages that would result from the standardization of market milk have just been stated under the preceding heading. Are there any disadvantages or objections? There may be.

(1st.) Without some kind of legal control, the result of standardizing or adjusting market milk would be the inevitable tendency to lower the composition of such milk to a point not much above the minimum legal standard, at present 3 per ct. of fat and 11.50 per ct. of milk solids in New York State. Market milk would not only tend to become fairly uniform the year around instead of varying as it now does, but unfortunately the uniformity would be in the direction of a lower percentage of fat than now prevails. The high value of milk-fat in the form of cream would exist as a constant temptation to standardize nearly all normal milk above 3.50 per ct. of fat to a lower fat content.

(2nd.) Milk cannot be standardized or adjusted without extra handling and this results in exposure to possible bacterial contamination. Without special care in manipulating milk when going through the process of standardization, the sanitary character may easily be unfavorably affected.

(3rd.) In the case of milks enriched by the addition of cream, the consumer gets somewhat less food value in solids-not-fat than he would in buying normal milk having the same percentage of fat. However, this difference is hardly large enough to constitute a serious objection.

(4th.) There is on the part of many consumers a vague feeling of objection to having anything done to market milk that affects its composition; and such persons think that standardizing should not be permitted under any conditions. For many years we have been careful to surround normal market milk with jealous legal protection and until recently to recognize as legal the sale only of normal milk whatever its composition. Many have thus come unconsciously to regard normal milk, that is, the milk produced by the cow, as something the composition of which should not be tampered with in any way, indeed, as something having an almost sacred kind of character. Of course, this is largely a matter of psychology rather than of dairy intelligence. We know that the composition of much normal market milk can be improved in some ways by standardization.

(5th.) Objection is likely to be made to the standardization of milk on the ground that the disturbance of the ratio of fat to solids-not-fat may have objectionable results in connection with the feeding of infants. This objection has little force when we consider the manifold ways in which normal milk is "modified" for infant

feeding, producing changes in composition much more extensive than take place when milk is standardized. On the other hand, standardization should result in greater uniformity of composition, a condition especially desired in case of milk for infants.

IV.— LEGAL CONTROL OF STANDARDIZATION OF MARKET MILK.

All who have devoted any thought to the subject of adjusted or standardized milk are agreed (1) that promiscuous, uncontrolled standardization should not be considered under any circumstances; (2) that, if such treatment of milk is permitted, it should be controlled by law as completely as practicable; (3) that this must be done in order to prevent the obviously objectionable conditions which would result from lack of such control.

Among the more important conditions that would be necessary to make standardization safe are the following:

(1) No one should be permitted to prepare standardized milk for market purposes without a special state license.

(2) Such conditions of standardizing processes should be prescribed as would insure no impairment of the sanitary quality of the milk.

(3) No standardized or adjusted milk should be permitted to be sold unless it conforms to the present legal minimum requirements in composition (3 per ct. of fat and 11.50 per ct. of solids). There are some who suggest that the minimum standard for standardized milk be placed at 3.25 per ct. of fat and 12 per ct. of solids.

(4) Some believe that all containers of such milk should be marked with the words "Standardized" or "Adjusted." There may be an honest difference of opinion as to whether this is necessary or desirable. Use of the word "standardized" on containers might easily be misleading to consumers as referring to superior quality, while the word "adjusted" might readily arouse unwarranted suspicion.

(5) Whatever other safeguards it may be judged desirable to place around the standardization of market milk and its sale, the belief cannot be expressed too strongly that *it is all-important to place on every container of standardized or adjusted milk in plain figures the minimum percentage of fat in milk*, which shall stand as a guaranty that the milk in the container contains not less than the specified amount of milk-fat. This would accomplish several important purposes, among which, briefly stated, are the following:

(1st.) It would serve as a check to prevent adjusting the fat in all market milk down close to the present legal minimum standard of 3 per ct.

(2nd.) It would enable every consumer of such milk to know the minimum percentage of fat in each lot of milk purchased.

(3rd.) It would afford an opportunity for each consumer to purchase milk with the approximate percentage of fat desired,

within reasonable limits, if there were any choice, and it would make it easily possible for the distributor or producer to furnish it.

(4th.) It would protect distributors and producers against unfair competition.

(5th.) It would have the tendency of helping to adjust or standardize the price of market milk in accordance with the composition of the milk furnished.

(6th.) The successful employment of such a method would probably have the ultimate effect of making the sale of milk on a guaranteed fat basis supersede entirely the present minimum legal standard method for all kinds of milk, whether normal or adjusted.

COUNTING BACTERIA BY MEANS OF THE MICROSCOPE.*

ROBERT S. BREED and JAMES D. BREW.

Because of frequent requests for a description of the direct microscopic technique used at this Station in the examination of milk, it has become necessary to issue a reprint of the essential portions of Technical Bulletin 49. A bibliography at the end of this circular gives a list of the papers referred to in the original bulletin. Papers issued since 1916 are also included.

GENERAL DESCRIPTION OF THE TECHNIQUE USED IN COUNTING BACTERIA IN MILK BY THE DIRECT MICROSCOPIC METHOD.

"In brief, the technique used in making counts of the number of bacteria in milk by the direct microscopic method is as follows: One hundredth of a cubic centimeter of milk or cream is measured by means of a *clean* capillary pipette accurately calibrated to discharge this quantity of milk. The milk or cream is deposited on a *clean* glass slide. By means of a stiff needle the drop of liquid is spread evenly over an area of one square centimeter and *dried quickly* in a warm place protected from dust, flies and cockroaches. The surface on which the slides rest must be level in order that the films may dry evenly."

"The dry smears are then prepared for microscopic examination by immersing the slide in xylol or other fat solvent for one minute or longer if desired. After this the slide is drained and dried, immersed in 70 to 90 per ct. grain or denatured alcohol for one or more minutes, then transferred to a fresh, saturated, aqueous solution of methylene blüe. Old or unfiltered solutions are to be avoided as they may contain troublesome precipitates. The slides remain in this solution for five seconds to one minute or longer depending on the effect desired. They are then rinsed in water to remove the surplus stain and decolorized in alcohol. This takes several seconds to minutes during which time the slide should be under observation in order that it may be removed from the alcohol before decolorization has proceeded too far. When the decolorization is completed the general background of the film should have a pale blue tint. Where staining has been prolonged a deep blue margin or deep blue central patches may persist. These deeply stained areas

*Reprint of Circular No. 58, 1918, which is condensed and reprinted from Technical Bulletin No. 49, pp. 31, 1916.

do not contain more bacteria than other parts of the film and may be removed, if troublesome, by decolorizing and restaining lightly."

"After drying, the slides are ready for microscopic examination or they may be filed away and preserved indefinitely. Poorly stained slides may be decolorized and restained as many times as necessary without any apparent injury. If desired, the films may be mounted in Canada balsam with cover glasses, but in routine work it is customary to apply cedar oil directly to the film for examination under an oil-immersion lens."

DETAILED DISCUSSION OF THE VARIOUS PROCESSES INVOLVED AND OF POSSIBLE ERRORS.

"*Collection of samples.*— Some comparative counts have been made in order to discover whether samples of milk taken in clean test tubes containing preservatives (formalin and corrosive sublimate) were as satisfactory for use in making microscopic counts as iced samples taken in sterile tubes. The results secured are not sufficient to warrant a positive statement, but indicate that samples taken with preservatives are fully as satisfactory as are iced samples and are more convenient to handle. When an effort was made to keep the preservative samples for days or weeks, it was discovered that there was a tendency for them to become less satisfactory on standing. This was not because the organisms lost their staining power or because of any growth of the organisms, but because many bacteria floated to the top with the cream while others fell to the bottom. Because of the fact that it was impossible to break up the compact cream which formed after the sample had stood for some time and also because some sediment remained even after thorough shaking of the tubes, the counts made at the end of days or weeks tended to be lower than they should have been."

"*Measurement of sample.*— There are two common ways of measuring the small quantities of milk required in the microscopic method of counting bacteria. One is by means of platinum loops and the other by means of capillary pipettes. Our experience leads us to believe that only a careless person would introduce large errors in measuring the quantity of milk required if pipettes are used and that loops large enough to carry 0.01 cubic centimeter are unsatisfactory."

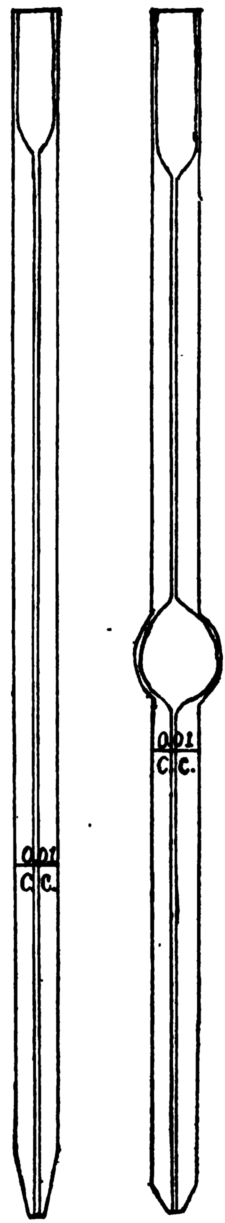
"*Form of pipette.*— At present nearly all of the reputable supply houses are making special capillary pipettes for use in connection with the microscopic examination of milk. The cheapest and most convenient forms are straight capillary-tube pipettes, discharging 0.01 cubic centimeter and long enough to reach the bottom of a test tube easily (Fig. 1). The bore of the pipette should be of such a size that the distance from the graduation mark to the tip is between 1½ and 2½ inches. A convenient form of pipette is also shown in Fig. 2. This has a reservoir just above the graduation mark which influences the filling of the pipette by capillarity in such a way that it fills to a point just above the mark."

"The milk in either type of pipette is easily controlled by first wiping the exterior of the pipette with a *clean* towel and then touching the tip of the pipette gently with the *clean* towel until the milk in the pipette is lowered to the mark. The tip of the pipette now being *clean*, the milk is blown out of the pipette very carefully so that all the milk possible is delivered."

"*Calibration of pipettes.*—The proper calibration of the pipettes has proved to be troublesome because of the fact that in discharging so small a quantity of milk as 0.01 cubic centimeter, the error due to adhesion of the milk to the inner walls and tip of the pipette becomes important. For this reason a large number of trials have been made to determine the amount of this error. Having determined, by repeated trials, the correct calibration of a pipette made to deliver 0.01 cubic centimeter of milk, specific gravity 1.032 at 21° C., it was found by experiment that such a pipette would contain .0104+ grams of distilled water at 21° C. or .1423 grams of mercury having a specific gravity of 13.552 at 21° C. In other words if these pipettes are calibrated with mercury, they should be so calibrated as to contain between .0104 and .0105 cubic centimeter of mercury in order to allow for the loss of milk due to adhesion to the glass."

"A convenient method of calibration with milk is to weigh the milk as discharged into the hollow of a clean, hollow-ground slide, covering the hollow with a clean cover glass to prevent evaporation, then from the specific gravity calculate the error and correct the graduation mark accordingly. All capillary pipettes should be recalibrated, as experience has shown that it is impossible to rely upon the accuracy of the best of the pipettes as supplied by dealers. Errors as large as 50 per ct. have been found in pipettes the accuracy of which was guaranteed. In all of our work we have taken the average specific gravity of milk to be 1.03 at 21° C. so that the weight of 0.01 cubic centimeter becomes 0.0103 grams."

"*Tip of the pipette.*— Experience has shown that milk is most easily discharged cleanly from a tip having the form of a truncated cone with the flat end, a circle of about 2 millimeters in



FIGS. 1 AND 2.— CONVENIENT FORMS OF CAPILLARY PIPETTES.

diameter. The angle of slope of the cone appears to make little difference. See Figs. 1 and 2."

"*Cleaning and sterilization of pipettes.*— In the original description of the microscopic technique, it was stated that it was necessary to use *clean pipettes* but that sterilization was unnecessary. This statement was made because of the fact that the rapid drying of the smear prevents the growth of the few accidental bacteria which get into the milk from clean glassware, while sterilization would not help the matter unless the bodies of the bacteria present were actually destroyed by the heat. The best way which has been found to clean the pipettes is to immerse them in an ordinary glass-cleaning solution containing sulphuric acid and potassium bichromate. They are afterward rinsed in clean water. If desired to dry them this may be accomplished quickly by using alcohol or ether."

"*Drying the smear.*— In describing this technique, the authors of this bulletin have always specifically stated that the smears should be dried quickly in a warm place and on a level surface. Too high a temperature will cause the films of dried milk to crack or peel from the glass. This drying can usually be accomplished within five minutes from the time the milk is deposited on the glass slide. It has always been felt that rapid drying was essential since the possibility that the bacteria would grow in the smear during the drying process was always present."

"*Dissolving the fat.*— Objection has been made to dissolving the fat out of the milk smears because of the possibility that the dissolving of the fat may mechanically remove some bacteria from the dried film of milk. The same objection holds in lesser degree in regard to later steps in the process such as washing in alcohol, staining, washing in water and the like. This objection was considered when the present technique was originally devised, but was disregarded when it proved to be impossible to demonstrate that bacteria were lost in this way. Abundant proof has now been secured from comparative counts made with the plate and microscopic methods which shows that this loss, if any, is negligible. Apparently the dried casein and milk albumin act as perfect fixatives. This result is not surprising when it is remembered that the bacteria in the milk do not occur in the fat drops, but float between them in a colloidal solution which readily coagulates on heating or in alcohol, embedding the bacteria in a semisolid coagulum which is not dissolved nor attacked in any subsequent process used in staining the films of dried milk."

"Xylol has generally been used in our work as a fat solvent, but ether, turpentine, gasoline or other fat solvents may be substituted where more convenient to use them. All act very quickly, but prolonged immersion of the dried films in these liquids causes no harm."

"*Danger of overlooking bacteria due to faulty staining.*— The discovery of this difficulty in connection with attempts to stain the bac-

teria in the milk itself raised the question whether the method of staining described in this bulletin succeeded in bringing out all of the bacteria. The need of investigating the matter was further emphasized by occasional results secured where comparative plate and microscopic counts were made. The counts of the number of individual bacteria in milk by means of the microscope are almost invariably several times greater than plate counts made on the same milk, but infrequently this relation is reversed and rarely comparative counts are secured where the plate count is very much higher than the microscopic count. Thus in the series of 450 comparative counts reported in Bulletin 373 there were two of this sort: One in which the plate count was 260,000 while the microscopic count was 100,000 and another in which the plate count was 2,150,000 and the microscopic count 960,000. Two striking instances of the sort have occurred in later comparative work, in one of which (microscopic count — 15,000, plate count — 1,500,000) a careful recount made by the microscopic method failed to reveal any explanation of the discrepancy while in the other case spore-like, unstained bodies which could be easily overlooked were found in the smear. An examination of the plates made from the same sample showed spore-forming bacteria to be present."

"These findings would indicate that faulty staining of dried films plays a very minor role in causing errors."

"*Fixation in alcohol.*— It is necessary to dry the slides after removing the fat because the solvents used do not mix with ordinary alcohol. Absolute alcohol may be used as an intermediary in passing from the fat solvent to the alcohol but is expensive and unnecessary. Seventy per ct. grain alcohol is strong enough to serve the purpose, but stronger alcohols may be used equally well or denatured alcohol may be substituted for the pure grain alcohol. Immersion in alcohol should be long enough to change the opaque whiteness of the smear to a semitransparent appearance. In our work it has occasionally happened that dried films of milk prepared from the milk of cows approaching the end of the lactation period have proved soluble in alcohol, but this is an unusual condition which at once becomes evident on placing the film in alcohol."

"*Staining.*— In practical work, the slides are usually transferred directly from the alcohol to the saturated methylene blue, but they may be dried at this stage without injury. Other stains may be used but none have proved as satisfactory as the aqueous solution of methylene blue. Stains containing alkalis should be avoided as they dissolve the smears. Loeffler's methylene blue, as commonly used in bacteriological laboratories, does not contain sufficient alkali to dissolve the smears, but should be avoided as there is no advantage in its use and frequently through carelessness or intent it contains enough alkali to cause trouble. Old stains containing precipitates should never be used as these may cling to the smears and cause trouble."

"*Slides.*— For many purposes it has been found to be convenient to use ordinary 1 x 3-inch microscopic slides, duplicate, triplicate or even quadruplicate smears being placed on the same slide. Various methods of marking out the one square centimeter areas have been tried, but none have been found to be more convenient than to place the slide over counting plates or other objects, the surface of which has been ruled in square centimeters. In routine work it has been found convenient to use larger-sized glass plates, cut from ordinary window glass and secured at any hardware store at a very small cost, in place of the 1 x 3-inch slides. In order to use as large a slide as possible on the stage of the microscope, a special mechanical stage was secured in which nearly the entire surface of 2 x 4½-inch slides could be examined. Special slides were also secured from Bausch and Lomb Optical Co. at a small cost, of the same size as those used for mounting the smears on which sixteen square centimeter areas are conveniently placed (see Fig. 3). These are used as guide plates, being placed under the slide on which the smears are to be mounted when in use. The margins of the window glass slides on which the smears are mounted are etched by a sand blast along a strip about ¼ inch in width (Fig. 4) in order to allow lead penciling labeling. These slides are filed away in an ordinary card filing case, 2-inch library cards being placed between the slides. Notes are frequently entered on these cards. In our routine work, only one smear is made from a sample, so that each slide carries the record of 16 samples of milk. The slides may be preserved indefinitely giving a valuable record for later comparisons or for reference in cases of dispute."

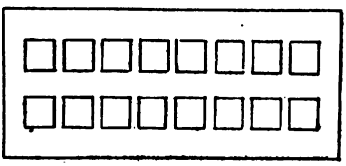


FIG. 3.—SPECIAL (2x4½ ins.) GUIDE-PLATE.

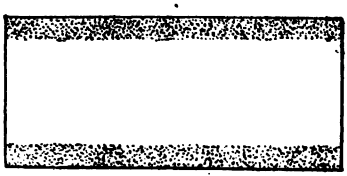


FIG. 4.—SPECIAL MICROSCOPE SLIDE (2x4½ ins.) WITH ETCHED MARGINS FOR LABELING.

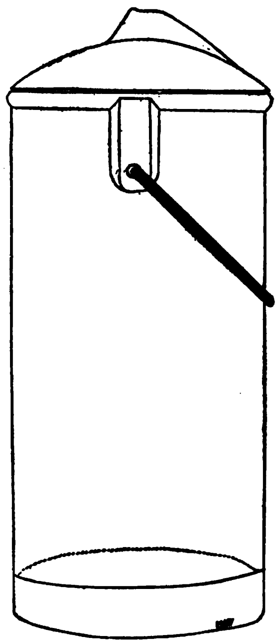


FIG. 5.—TYPE OF WIDE-MOUTHED SPECIMEN JARS USED IN STAINING SLIDES.

STANDARDIZATION OF THE MICROSCOPE.

"If the proper ocular is selected for use with the oil-immersion lens and the draw tube adjusted, the area of the microscopic field can be made of such a size that it gives a simple figure for use in computations. Thus if the diameter of the field is .16 millimeter the area covered by each field of the microscope is approximately 1–5000 square centimeter (actually 1–4975 square centimeter). Under these conditions each bacterium seen in a field is equivalent to 500,000 bacteria per cubic centimeter of milk, or if the total number of bacteria seen in 100 fields of the microscope are counted, each individual seen is equivalent to 5,000 per cubic centimeter. This gives a somewhat higher magnification than is necessary for counting bacteria."

"After much experience it has, therefore, become our custom to use a field of such a size that it gives a 300,000 factor for computation. This is secured by adjusting the draw tube so that the diameter of the field is .205 millimeter. In this case the number of bacteria in a single field of the microscope multiplied by 300,000 (actually 302,840), or the total number of bacteria in thirty fields multiplied by 10,000, or the total number of bacteria in 100 fields multiplied by 3,000 gives the total number of bacteria per cubic centimeter."

"There is an objection to using the whole field of the microscope for observation in that only the center of the field of any oil-immersion lens gives sharp definition. With as low a magnification as that which gives the 300,000 factor, poor definition at the edges of the field does not cause serious trouble except with poorly stained smears or where the number of bacteria present is large. This difficulty is entirely obviated by using a special ocular micrometer of the form shown in Figure 6. For use with a Bausch and Lomb Optical Co. ocular 6.4x, a circle of 8 millimeters diameter will be found to be very convenient. If the draw tube is so adjusted that the diameter of the circle becomes .146 millimeter then the factor necessary for computation becomes 600,000 (actually 597,708). Ocular micrometers bearing additional circles are convenient for use in some cases, but the markings shown are sufficient for ordinary use. Additional lines are troublesome as they tend to obscure bacteria."

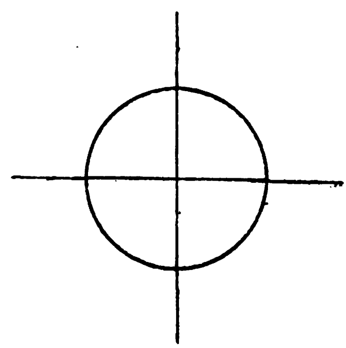


FIG. 6.—FORM OF GUIDE LINES USED ON SPECIAL OCULAR MICROMETER

DIFFICULTIES INVOLVED IN COUNTING.

"The chief immediate practical value of this technique is for use in the rapid grading of milk. For routine work with samples of fresh milk, a search through twenty to thirty fields of the microscope is sufficient to answer the question whether so few bacteria are present that none can be readily found, whether they occur in scattering groups, or whether they are so abundant that every field of the microscope shows them in large numbers. These three conditions correspond roughly to the three grades of milk established by the New York State and the New York City Codes. The picture presented to the eye, when these preparations are viewed under the microscope, is similar to that presented by the colonies on petri plates. Smears which show intermediate conditions must be examined carefully and counting resorted to if the sample is to be graded accurately. The number of these border line samples is ordinarily relatively few, but will vary according to the general quality of the milk which is being sampled."

"Certain chances of error are present in the microscopic technique, the most important of which seems to be

1. Faulty measurement of the original sample of milk.
2. Growth of bacteria after the sample is taken, especially in the drop of milk while it is drying.
3. Inaccurate counting due to carelessness, poor preparations, differences in judgment as to what constitutes an individual or group, or to mistaking objects for bacteria which are not bacteria.
4. Irregular distribution of bacteria in clumps of irregular sizes. Where a milk contains clumps of bacteria of large size, it is impossible to make a satisfactory count of the number of indivdiual bacteria.

Sources of error commonly urged which do not seem to play any important part in causing errors are:

1. Error due to small amount of milk examined. This error averages no larger for the microscopic technique than for the plating technique. The amount of milk ordinarily examined by the microscope is less than that examined by the plate count in low-count milks, but is larger in the case of high-count milks.
2. Errors due to washing bacteria out of smears, or to adding them by the use of unsterilized pipettes, washing from smear to smear, and the like.
3. Errors due to the counting of dead bacteria. Very few dead bacteria occur in fresh, unpasteurized milks. Moreover, if they do occur, they are as significant in interpreting the past history of the milk as are living bacteria."

PRACTICAL APPLICATION OF THE MICROSCOPIC EXAMINATION OF MILK TO COMMERCIAL GRADING.

"In practical use it has been found possible to determine whether a given sample of milk will give a plate count less than 60,000, less than 200,000 or less than 1,500,000 with a relatively small percentage of error. Thus this technique has a large field of usefulness for milk dealers who wish to determine quickly and cheaply whether the milk which they are handling will conform to requirements which they are compelled to meet. At least three milk companies in the State have been making use in this way of the microscopic technique here described with such satisfactory results that they expect to continue and extend its use.

The Station has at the same time been making a practical test of the technique in an experimental way in connection with local milk control work. After a preliminary trial, in which entirely satisfactory results were secured, contracts were drawn up between two local milk companies and the producers making the microscopic examinations of their milk by the Station the basis for payment. This system has now been in force since April 1, 1915, and has given satisfaction to all parties concerned. Frequent comparative counts made by the microscopic and the plate methods have given clear indication that the farmers received fairer treatment from the use of the microscopic method of grading than they would have received if the plate method of grading had been used. This has come about largely because it has been possible to make a weekly examination of each individual can of milk brought in by each man. Likewise, fairer judgment as to the quality of the milk is secured, where it is possible to recognize not only the numbers but also the morphology of the bacteria present as is always the case when the milk is examined by the microscopic method. In this way instances have been detected where the sole cause of the high-count milk brought in by individual farmers was due to the milk of cows with a streptococcus infection. No difficulty was encountered in stopping the presentation of this type of milk at the milk stations, for the farmers were only too glad to find the source of the trouble which caused their income from the sale of the milk to become less.

"In this milk control work one person prepares his collecting case, goes to the milk station one mile distant and collects forty to seventy samples of milk, returns to the laboratory, prepares the smears, examines them and has the results of the examination ready to be mailed to the individual farmers within five hours. During one week every can of milk delivered at one of the milk stations was examined, all of the work being done by one person."

A detailed description of this experimental milk control work will be found in Bulletin 443 of the Station, entitled "The control of bacteria in market milk by direct microscopic examination."

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REPORT

OF THE

Department of Botany.

F. C. Stewart, *Botanist.*

W. O. Gloyer, *Associate Botanist.*

M. T. Munn, *Assistant Botanist.*

TABLE OF CONTENTS.

REPORT OF THE DEPARTMENT OF BOTANY.

SEED TESTS MADE AT THE STATION DURING 1916–1917.*

M. T. MUNN.

SUMMARY.

Part I.— Of the 906 official samples of agricultural seeds collected by agents of the Commissioner of Agriculture during the past two years and forwarded to this Station for examination, 51, or 5.6 per ct., were found, upon analysis, to be violations of the seed law. Altho containing more than 3 per ct. of foul or foreign seeds they were not so labeled. The usual amount of unlabeled goods containing seeds of dodder and other noxious weeds and excessive amounts of inert matter was found. Apparently, these lots of seeds, many of them unsafe and even valueless for seeding purposes, were being sold without labels and as choice or prime grade.

A careful study of the results of the seed inspection since the adoption of the present seed law shows some benefits derived from the inspection and also some serious defects of the law, but fails to show an appreciable improvement in the quality of the seeds upon New York markets or in the conditions under which they are offered for sale. The number of violations of the law has decreased noticeably, while the number of labeled lots of seed has increased. Nevertheless, the present seed law, which permits 3 per ct. of weed seeds and any amount of inert matter to be sold in crop seeds without being so labeled, is too tolerant. It affords the purchaser but little protection. It has not, and apparently cannot, attain the objects of a good seed law, namely, to give the purchaser protection and information and to protect the honest seedsman and seed dealer against careless and dishonest ones.

The remedy suggested is to substitute for the present inadequate seed law the provisions of the "Uniform State Seed Law" drafted by the Association of Official Seed Analysts of North America and approved by the American Seed Trade Association. This law, if

* Reprint of Bulletin No. 446, January, 1918.

adopted, and administered under our present system of inspection, would carry, in addition to its regulatory value, unlimited educational possibilities for the purchaser of seeds. The United States Government has suggested, as a war emergency measure, and the best agricultural interests of the State demand, that all lots of seed containing ten pounds or more and sold for seeding purposes should bear uniform label information.

Part II.— Examination of the 1251 samples of seeds received from correspondents for purity test during the two years plainly shows the great need for uniform labeling of all seeds sold for seeding purposes. There is much impure and worthless seed upon the market. The present seed inspection law provides but little protection to the purchaser. Field-crop seeds loaded with inert matter and containing many seeds of dodder and other noxious weeds are sold at will, and without labels. Uncleaned, weedy, and dirt-laden lots of seed, legally unsalable in adjoining states, have been shipped into this State where a very lenient seed law permits their sale without any declaration as to the nature or quantity of the impurities which they contain. At the present time, when every effort is being made to increase crop production, purchasers of seeds may reasonably insist upon guarantees of purity and germination on all seed purchases. The Government has suggested that seed dealers furnish such label information. The farmer should demand it or else be prepared, himself, to make purity and germination tests of his seed purchases. Every farmer should know exactly what he is planting.

I. INSPECTION OF AGRICULTURAL SEEDS.

Part I of this bulletin gives the results of the analyses of the official samples of agricultural seeds collected during the years 1916 and 1917. These samples were collected under the provisions of Article 15 of the Agricultural Law and were transmitted for analysis to the Director of the New York Agricultural Experiment Station, in accordance with the provisions of Section 341 of said law.

These analyses, reported on pages 9 to 50, and other additional information are published by the Director in accordance with said Section 341. Article 15 of the Agricultural Law, or what is known as the "Seed Law," will be found on page —, printed in full. Section 52 of the Agricultural Law relates to penalties.

COMMENTS ON RESULTS OF INSPECTION 1916 AND 1917.

During the past two years agents of the Commissioner of Agriculture have collected and forwarded to this Station for analysis 906 samples of seeds. As shown by Table I, 566 of these were analyzed in 1916 and 340 in 1917.

AS REGARDS PURITY.

Slightly over 11 per ct. of the samples analyzed during these two years contained seeds of noxious weeds, seeds of troublesome weeds, or inert matter in such quantity as to make the crop seed objectionable for seeding purposes. In other words, approximately one lot of seed in every ten represented by these samples showed some serious defect. Some were unsafe to sow, some would not produce a profitable crop and others contained so small a proportion of pure, viable seed as to be very dear in price.

Over 3 per ct. of the alfalfa and red clover seed samples contained seeds of dodder. Also, two samples of alsike clover and one sample of timothy were found to contain dodder seeds.

VIOLATIONS.

Approximately 5 per ct. of all the samples collected and analyzed during the past two years were violations of the provisions of the seed law, that is to say, the crop seed contained over 3 per ct., by weight, of foul or foreign seeds and was not so labeled. In this connection the term "foul or foreign seed" as found in the seed law, is interpreted to mean seeds of weeds and seeds of cultivated plants other than the kind purported to be offered for sale.

A few vendors of seed were prosecuted simply because of failure to label their seed which, tho of excellent quality, contained over 3 per ct. of another kind of crop seed. These were usually cases in which white clover or timothy was found in alsike clover.

LABELING.

While the present seed law does not specify what information the label must convey to the prospective buyer except that the percentage of foul or foreign seed must be stated when it exceeds 3 per ct. by weight, over 10 per ct. of the samples submitted for analysis bore evidence that some sort of labeling had been attempted.

For the completeness and accuracy of this labeling (revealed by the results of our analyses) responsibility rests with the seed houses from which the lots of seed were originally obtained. In addition to the 10 per ct. of seed offerings which were violations of the law, there was an additional 2 per ct. which would have been violations had it not been for the fact that they were labeled.

The fact that a certain percentage of the lots of seed upon the market were labeled in some manner is of little relative importance when it is considered that many lots of unlabeled seed contained appreciable amounts of the seeds of noxious and troublesome weeds. As an illustration, one particular sample of red clover seed contained a total of approximately one per ct. of the seeds of six noxious weeds. However, because of the lenient requirements of the present seed law, it passed on the market as good seed.

CONCLUSIONS.

While the results of the 1916 and 1917 inspection are fairly satisfactory when compared with those of previous years, their failure to show improvement in the quality of the seeds offered is to be regretted; as is, also, the fact that altogether too many lots of seed were on the market without any label or identification mark to acquaint the purchaser with the fact that they contained noxious weed seeds or excessive amounts of inert matter. Furthermore, a study of the analyses of the violations as listed in Table II shows that many of them were violations of the law mainly because the crop seed contained seeds of another crop plant of about the same size and weight and often of equal or higher value. During the past two years an average of 51 per ct. of the so-called "violations" have been lots of alsike clover contaminated with either white clover or timothy seed or both — a condition which does not make the crop seed especially objectionable for seeding purposes. On the other hand, all of the lots of seed represented by samples which did not contain over 3 per ct. of foul or foreign seed passed onto the market without labels to warn the buyer of the serious defects of many of them.

The inspection of seeds under the present law is, in a small way, teaching buyers the value of labeling seeds so as to show the names and percentages of the various ingredients in the package. The danger in depending solely upon percentage composition as required

by the present seed law is found mainly in the fact that a very small amount of certain weed seeds makes the crop seed very unsafe for seeding purposes. The nature of the seed impurities is often of more importance than the number or percentage present.

RESULTS OF THE ENFORCEMENT OF THE SEED LAW.

Since July 1, 1912, six seasons, 2034 seed samples have been collected officially. Of these, 33 samples were discarded, since they represented crops not enumerated in the seed law. Accordingly the average number of official samples collected and analyzed annually is 335.

TABLE I.— EFFECT OF THE NEW YORK SEED LAW ON THE QUALITY OF SEED OFFERED FOR SALE IN THE STATE AS SHOWN BY ANALYSES OF OFFICIAL SAMPLES.

YEAR.	Number of samples analysed.	Percentage of samples labeled.	Percentage of samples which were violations.	Percentage of samples containing dodder.	Percentage of samples containing seeds of noxious weeds or otherwise objectionable for seeding purposes.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
1912*	189	0.0	20.8	3.2	7.3
1913	292	0.0	17.5	3.4	10.6
1914	303	0.0	10.9	1.9	11.4
1915	323	3.3	4.6	1.2	5.8
1916	566	10.6	4.9	4.0	12.3
1917	340	9.0	5.0	2.3	10.6

* July 1, 1912, to January 1, 1913.

It will be noted that the records of the six years of seed inspection reveal some benefits derived therefrom as well as some serious defects of the law. One of the apparent benefits of the seed inspection, as noted from a glance at the above table, is that the percentage of samples which were violations has gradually decreased since the adoption of the seed law. However, this apparent benefit loses part of its significance when it is observed that the number of labeled samples has increased considerably. As stated in a preceding paragraph, many of these labeled lots of seed contained over 3 per ct. of foreign seed and would have been violations had it

not been for the fact that they were labeled in such a manner as to meet the requirements of the law. Furthermore, the fact that increasing numbers of lots of seed are labeled does not necessarily mean that the quality of the seed sold in the State has been improved. Labels are of value only in so far as the statements which they contain are complete and truthful. The purchaser can find out, if he will, whether or not they are truthful.

The percentage of samples containing seeds of dodder, one of our most noxious weed pests, has remained practically, unchanged. Furthermore, and more important, all of these dodder-laden seeds were offered for sale without any warning to the purchaser that they contained seeds of dangerous weeds. Positive evidence has been secured on several occasions * and during nearly every season, that shipments of crop seeds loaded with seeds of dodder and other objectionable material have been diverted into this State from adjoining states where they could not comply with the seed laws.

The statements in the above paragraph concerning dodder seeds are equally true for other noxious weeds. Also, they are true of those containing large amounts of inert matter (including dirt, chaff and refuse of all kinds), and old, dead seeds. The time has arrived when New York State should cease to be the dumping ground for all sorts of unlabeled, nondescript and undesirable lots of seeds which cannot be sold elsewhere.

Altho sweet clover is not mentioned in the seed law, one sample of white sweet clover was collected. It was analyzed and found to contain over 3 per ct. of weed seeds. This indicates that sweet clover should be included in the list of agricultural seeds subject to inspection. Of all the official samples of alfalfa seed analyzed only one has proved to be a violation of the seed law. However, many of them contained seeds of dodder and other noxious weeds which made them unsafe for seeding purposes.

CONCLUSIONS AND RECOMMENDATIONS.

The results of the seed inspection permit of but one conclusion; namely, that the inspection under the requirements of the present law has not, and apparently cannot, accomplish the objects for which such a law is designed, that is, to protect and furnish information to the purchaser of seeds and to protect the honest seedsman,

* Vt. Agr. Expt. Sta. Bul. 183, p. 294. 1914.

dealer or agent against careless or dishonest ones. The one very lenient provision of the present law cannot attain these objects. A law which allows 3 per ct. of foul or foreign seeds and any amount of inert matter to be sold with crop seeds without being labeled is entirely too tolerant. Since farm crop seeds are very variable in quality and, weight for weight, the most expensive material which the farmer purchases, it is obvious that every bag of seed, like other commodities, should be labeled and sold for what it really is. The buyer can then decide for himself whether or not he wants the quality offered, or on the other hand, the objectionable materials it may contain.

The proper remedy for this condition is to write into the Agricultural Law of the State the provisions of the "Uniform State Seed Law" proposed by the Association of Official Seed Analysts of North America.* This law is based upon the experience of many States with seed laws and has been approved by the American Seed Trade Association. Such a law should, and undoubtedly will, receive the support of the seedsmen of the State. In fact, certain of them are already carrying out, voluntarily, at the suggestion of the Government, many of the requirements of the proposed law in the labeling of seeds. The labeling requirements are very complete and plainly stated. Under our present system of inspection such a law would not only accomplish the principal objects of a seed law, but would have, also, high educational value for the purchaser of seeds.

PROVISIONS OF THE AGRICULTURAL LAW RELATIVE TO THE INSPECTION AND SALE OF AGRICULTURAL SEEDS.

ARTICLE 15 OF THE AGRICULTURAL LAW.

INSPECTION AND SALE OF SEEDS.

Section 340. Inspection and sale of seeds.
341. Samples, publication of results of examination.

§ 340. **Inspection and sale of seeds.** Within the meaning of this article "agricultural seeds" are defined as the seeds of alfalfa,

*Proceedings of the Association of Official Seed Analysts of North America, Tenth Annual Meeting, June 19-21, 1917, Detroit, Mich. Also in *The Seed World*, 3:No. 9: 460-461, Sept., 1917, Chicago, Ill.

Canadian blue grass, Kentucky blue grass, alsike clover, crimson clover, red clover, white clover, vetch, orchard grass, rape, redtop, and timothy which are to be used for sowing or seeding purposes. No person, firm or corporation shall sell, offer, expose or have in his possession for sale for the purpose of seeding, any seeds of grasses or clovers, of the kind known as agricultural seeds, containing in excess of three per centum by weight of foul or foreign seeds, unless every receptacle, package, sack or bag containing such seeds is plainly marked or labeled with the per centum of such foul or foreign seeds contained therein. (*As amended by chapter 59 of the Laws of 1914.*)

§ 341. **Samples, publication or results of examination.** The commissioner of agriculture or his duly authorized representatives shall take samples of seed in triplicate in the presence of at least one witness and in the presence of such witness shall seal such samples and shall at the time of taking tender, and if accepted, deliver to the person apparently in charge one of such samples; one of the other samples the commissioner of agriculture shall cause to be analyzed. The director of the New York agricultural experiment station shall analyze or cause to be analyzed such samples of seeds taken under the provisions of this article as shall be submitted to him for that purpose by the commissioner of agriculture and shall report such analysis to the commissioner of agriculture, and for this purpose the New York agricultural experiment station may employ experts and incur such expenses as may be necessary to comply with the requirements of this article. The result of the analysis of the sample or samples so procured, together with such additional information as circumstances advise, shall be published in reports or bulletins from time to time. (*As amended by chapter 297 of the Laws of 1912.*)

TABLE II.—REPORT OF ANALYSES OF SAMPLES OF SEEDS COLLECTED BY THE COMMISSIONER OF AGRICULTURE DURING 1916 AND 1917.

Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALFALFA:	Per ct.	Per ct.	Per ct.	Per ct.
1889	Alfalfa Buyea & Standt, Oneida.	.45	.12	99.43	......
2215	Alfalfa Philip Deuchler & Son, Lyons.	*F .06 *L	.12	99.82 99.75	....
2255	Alfalfa Fred H. Ebeling, Syracuse.	.08	.30	99.62	......
2820	Alfalfa Chris. Fox, St. Johnsville.	.09	.36	99.55	......
2703	Alfalfa Peter Henderson & Co., New York.	.06	.27	99.67	......
2299	Alfalfa Carter Huested, Kings Ferry.	.03	.24	99.73	......
2400	Alfalfa A. G. Johnson, Jamestown.	F .02 L ...	.12	99.86 99.75	....
2289	Alfalfa Marcellus Hardware Co., Marcellus.	.03	.40	99.57	......
2251	Alfalfa Benj. F. Metcalf & Son, Syracuse.	.09	.14	99.77	......
P 103	Alfalfa Morris Brothers, Oneonta.	.02	.15	99.83	......
738	Alfalfa Phelps & Sibley Co., Cuba.	.08	.34	99.58	......
P 4	Alfalfa Elmer G. Porter, Caywood.	F .08 L .40	.21 .40	99.71 99.20	....
2712	Alfalfa Stumpp & Walter Co., New York.	F .01 L ...	.69	99.30 99.00	....
2714	Alfalfa J. M. Thorburn & Co., New York.	.06	.24	99.70	......
2829	American Mohawk Valley Co-Op. Co., Fort Plain.	.76	.19	99.05	......
2811	American Grown Fancy Mrs. Annette E. Bellinger, Canajoharie.	.10	.15	99.75	......
2672	American Grown Fancy Charles H. Borden & James F. Elliott, Sidney.	.18	.29	99.53	......
1828	American Grown Fancy E. W. Conklin & Son, Inc., Binghamton.	.25	.30	99.45	......
2573	American Grown Fancy Harry W. Hall, Himrod.	.27	.37	99.36	......
2292	Anchor Carr-Leggett Hardware Co., Port Byron.	.12	.19	99.69	......
729	Anchor Weinhanger & Co., Clarence.	.05	.50	99.45	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	KIND OF SEED, BRAND OR TRADE NAME, NAME OF DEALER, AND PLACE OF COLLECTION.	COMPOSITION.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALFALFA (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 152	Best	.11	.03	99.86	......
	Griggs & Ball Co., East Aurora.				
720	Bride	.57	1.05	98.38	......
	Jamestown Electric Mills, Jamestown.				
P 3	Choice	.21	.41	99.38	......
	Charles O. Drake, South Lansing.				
P 9	Choice	.22	.41	99.37	......
	Oliver William Hill, McDougall.				
2291	Climax Superfine	.07	.25	99.68	......
	Charles D. Loomis, Port Byron.				
2597	Climax Superfine	.05	.10	99.85	......
	Wm. M. Pellett, Watkins.				
2258	Empire	.04	.26	99.70	......
	Wilbur M. Jones, Fayetteville.				
2229	Eureka	.05	.24	99.71	......
	Clyde Farmers Exchange, Clyde.				
2372	Eureka	Trace	.17	99.83	......
	James O. Rignel Co., Inc., Lockport.				
1868	Eureka	.03	.07	99.90	......
	Smith Bros. Seed Co., Inc., Auburn.				
2864	Fancy	Trace	.30	99.70	......
	E. F. French & Son, Attica.				
1888	Fancy Northern Grown	.03	.23	99.74	......
	Buyea & Standt, Oneida.				
2578	Fancy Northern Grown	.02	.13	99.85	......
	T. Magnus Larsen, Dundee.				
2230	Fullwerth	.01	.16	99.83	......
	Clyde Farmers Exchange, Clyde.				
713	Fullwerth	.15	.26	99.59	......
	Jamestown Electric Mills, Jamestown.				
2360	Gandy's Fancy Standard " A "	.05	.09	99.86	......
	W. D. Hatch, Holley.				
2246	Gandy's Fancy Standard " A "	*F .71	.15	99.14	......
	Perry C. Schafer Co., Brockport.	*L ...	....	99.00	......
2239	Globe	.02	.60	99.38	......
	Burr & Starkweather Co., Rochester.				
1819	Globe	.18	.36	99.46	......
	Craver-Dickinson Seed Co., Binghamton.				
2358	Globe	.03	.21	99.76	......
	W. D. McGrillen & Co., Holley.				
2830	Globe	.24	.66	99.10	......
	Stemple & Smith, Fort Plain.				
2273	Grand Champion	.08	.03	99.89	......
	The Biggs Company, Trumansburg.				
2228	Honor	.11	.31	99.58	......
	Clyde Farmers Exchange, Clyde.				

* F and L stand, respectively, for Found and Labeled.

Table II.— Analyses of Samples of Seeds Collected (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALFALFA (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1862	Honor John Dix, Skaneateles.	Trace	.04	99.96	......
1950	Honor J. J. Martin, Perry.	.04	.02	99.94	......
2263	Honor D. Quinlan & Son, Jamesville.	.09	.17	99.74	......
1838	Honor The Standford Seed Co., Inc., Binghamton.	.10	1.04	98.86	......
P 5	Oriole Elmer G. Porter, Caywood.	*F .27 *L .20	.20 .30	99.53 99.50	....
2249	Pan American Perry C. Shafer Co., Brockport.	.01	.50	99.49	......
2203	Pax Brewster Crittenden Co., Rochester.	.12	.28	99.60	......
2367	Pine Tree The J. T. Darrison Co., Lockport.	.11	.04	99.85	......
1894	Pine Tree Rhody Toher, Oneida.	.53	.10	99.37	......
1943	Pine Tree Roche Cash Store, Perry.	.27	.04	99.69	......
2580	Pine Tree State Agr'l & Industrial School, Industry.	.09	.37	99.54	......
2851	Planet Joseph Meehan, Batavia.	.36	.26	99.38	......
2384	Value Austin & Rowley, Medina.	F .11 L	.10	99.79 99.75	....
	ALSIKE CLOVER.				
2575	Alsike Clover Beekman, Clary & Van Liew, Dundee.	.44	.17	99.39	......
2671	Alsike Clover Borden & Elliott, Sidney.	F 3.14 L 3 05	2.59	81.63	12.64 12.95
2885	Alsike Clover William Bowen, North Collins.	F .22 L	1.00	98.78 99.84	....
2285	Alsike Clover Brace, Eaton & Brace, Jordan.	5.49	1.12	93.39	......
2202	Alsike Clover Brewster, Crittenden Co., Rochester.	.25	.30	99.45	......
2204	Alsike Clover Brewster Crittenden Co., Rochester.	.30	.70	99.00	......
2295	Alsike Clover Rudolph F. Chappins, Dryden.	F 3.92 L 3.05	3.27	80.06	12.75 12.95
2877	Alsike Clover Howard B. Clark, Castile.	.48	1.86	97.66	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALSIKE CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2881	Alsike Clover......................... Howard B. Clark, Castile.	1.80	2.02	96.18	......
704	Alsike Clover......................... O. W. Clark & Son, Buffalo.	.54	.91	98.55	......
1857	Alsike Clover......................... Cole-Leggett Hardware Co., Baldwinsville.	.25	.64	99.11	......
2216	Alsike Clover......................... Philip Deuchler & Son, Lyons.	.22	1.76	98.02	......
1865	Alsike Clover......................... John Dix, Skaneateles.	1.70	.64	97.66	......
P 1	Alsike Clover......................... Charles O. Drake, South Lansing.	3.62	1.80	88.13	6.45
2252	Alsike Clover.........................	*F 2.80	1.46	93.37	2.37
	Fred H. Ebeling, Syracuse.	*L 2.19	....	....	1.89
2666	Alsike Clover......................... Samuel Harley, Grand Gorge.	1.88	.74	97.38	......
2213	Alsike Clover......................... Hawkins Hardware Co., Geneva.	1.33	.51	98.16	......
2705	Alsike Clover......................... Peter Henderson & Co., New York.	.02	.13	99.85	......
1587	Alsike Clover......................... William R. Jenkins, Schenevus.	3.15	.48	96.37	......
707	Alsike Clover......................... A. G. Johnson, Jamestown.	5.37	1.47	93.16	......
2890	Alsike Clover......................... Law & Wilber, Collins.	.52	.38	99.10	......
2290	Alsike Clover......................... Marcellus Hardware Co., Marcellus.	1.95	1.24	96.81	......
2563	Alsike Clover.........................	F 1.17	.45	98.74	8.64
	Marshall-Barrick Co., Lyons.	L 0.40	....	....	6.64
2210	Alsike Clover......................... R. A. Mather, Canandaigua.	1.55	.45	98.00	......
2211	Alsike Clover......................... R. A. Mather, Canandaigua.	2.11	2.07	95.82	......
1579	Alsike Clover......................... Steward C. Millard, Otego.	16.06	2.96	80.98	......
P 101	Alsike Clover......................... Morris Bros., Oneonta.	1.45	.47	98.08	......
2281	Alsike Clover.........................	F 4.52	.61	94.87	......
	Lawren F. Noxon, Ithaca.	L 3.34	....	....	......
2262	Alsike Clover......................... D. Quinlan & Son, Jamesville.	1.00	.83	98.17	......
1875	Alsike Clover......................... Daniel J. Ramsey & Son, Auburn.	2.08	1.25	96.67	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	KIND OF SEED, BRAND OR TRADE NAME, NAME OF DEALER, AND PLACE OF COLLECTION.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALSIKE CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1877	Alsike Clover Daniel J. Ramsey & Son, Auburn.	1.14	1.45	97.41	......
1878	Alsike Clover Daniel J. Ramsey & Son, Auburn.	1.41	.56	98.03	......
2376	Alsike Clover James O. Rignel Co., Inc., Lockport.	1.23	3.79	94.98	......
2353	Alsike Clover Rowe & Kennedy, Canaseraga.	5.70	.27	94.03	......
1896	Alsike Clover Charles F. Saul, Syracuse.	10.35	.59	89.06	......
2378	Alsike Clover W. E. Shaeffer, Lockport.	2.90	6.19	90.91	......
2379	Alsike Clover W. E. Shaeffer, Lockport.	.80	2.83	96.37	......
2247	Alsike Clover Perry C. Shafer Co., Brockport.	2.31	.50	97.19	......
1569	Alsike Clover Stevens & Converse, Cooperstown.	5.04	.24	94.72	......
2717	Alsike Clover J. M. Thorburn & Co., New York.	1.74	.89	97.37	......
2583	Alsike Clover Clarence J. Tierney, Wallace.	2.06	1.68	96.26	......
2368	Alsike Clover John Young, Lockport.	*F 3.44 *L 2.00	.76 10.00	95.29 85.00	.51 3.00
2369	Alsike Clover John Young, Lockport.	F .60 L 2.00	4.04 1.00	92.73	2.63 2.00
1873	Ace Auburn Flour & Feed Co., Auburn.	F 1.77 L 4.00	.52	94.89	2.82 2.75
1572	Ace H. D. & I. E. Cole & Son, Cherry Valley.	4.08	1.43	94.49	......
1812	Ace Craver-Dickinson Seed Co., Binghamton.	4.31	.55	95.14	......
2232	Ace Ketchum & Maloy, Clyde.	F 1.00 L 1.25	.62	95.48	2.90 2.00
2395	Ace Frank A. Rinn, Gasport.	F .52 L 1.50	.89	96.59	2.00 3.25
1891	Ace Rhody Toher, Oneida.	F 4.34 L 4.30	.55	95.11	....
1364	Ace Van Epps & Dunn, Fultonville.	F 1.85 L 1.25	.67	94.18	3.30 1.25
739	Alice Phelps & Sibley Co., Cuba.	.50	.47	99.03	......
2655	Arc Samuel A. Dugan, Margaretville.	2.54	.65	96.81	......
2664	Arc Hanford Bros., East Meredith.	2.45	.27	97.28	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALSIKE CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1584	Arc Berth E. McIntosh, Unadilla.	3.45	.32	96.23	......
2887	Arc Joseph Theil, North Collins.	1.95	.29	97.76	......
2363	Best W. D. Hatch, Holley.	.48	.41	99.11	......
2582	Best Kimmel Hardware Co., Wayland.	.42	.08	99.50	......
P 10	Choice Oliver William Hill, McDougall.	.08	.25	99.67	......
2574	Choice C. M. Harry W. Hall, Himrod.	*F 1.40 *L .75	.45	94.58	3.57 2.75
2269	Choice C. M. Halsey P. Minor, Interlaken.	F 1.30 L .69	.50	94.95	3.25 2.75
2805	Choice C. M. Fred C. McRae & Co., Schuylerville.	F 1.31 L .75	.69	93.97	4.03 2.75
2871	Contract Prime Wm. Watson & Son, Warsaw.	.31	.21	99.48	......
1856	Climax Superfine James N. McKeon, Seneca Falls.	2.11	.29	97.60	......
2386	Eureka S. P. Blood & Co., Medina.	.21	.32	99.47	......
1362	Eureka Arthur Hill & Co., Amsterdam.	.40	.27	99.33	......
2235	Eureka Judson Snyder, Newark.	.53	.29	99.18	......
2240	Fancy Burr & Starkweather Co., Rochester.	F .05 L .15	.86 1.08	97.77 97.74	1.32 1.03
2222	Fancy Clyde Farmers Exchange, Clyde.	.95	.26	98.79	......
2863	Fancy B. F. French & Son, Attica.	.16	1.44	98.40	......
2351	Fancy J. J. Martin, Perry.	1.41	.05	98.54	......
731	Fancy L. Y. Miller & Sons, Olean.	1.25	.95	97.80	......
2569	Fancy State Agr'l & Industrial School, Industry.	1.22	1.09	97.69	......
2357	Fancy Empire Canada Albion Flour & Grain Co., Albion.	.91	.35	98.74	......
2220	Fullwerth Clyde Farmers Exchange, Clyde.	.16	.13	9.71	......
2562	Gandy's Fancy Gipson Meade, Savannah.	F .64 L	.45	98.91 98.75	....

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALSIKE CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1810	Globe. Craver-Dickinson Seed Co., Binghamton.	.88	.42	98.70	......
2391	Globe. A. G. Criswell, Medina.	*F .35 *L .50	.41	98.47	.77 .75
1876	Globe. Daniel J. Ramsey & Son, Auburn.	1.17	.22	98.61	......
1365	Globe. Van Epps & Dunn, Fultonville.	F .52 L .50	.37	98.11	1.00 .50
2868	Honor. Byron Produce Co., Byron.	1.14	.55	98.31	......
2260	Honor. Wilbur M. Jones, Fayetteville.	1.75	.60	97.65	......
2250	Honor. Upton & Brown, Spencerport.	.68	.17	99.15	......
1829	Imperial. E. W. Conklin & Son, Inc., Binghamton.	1.42	.85	97.73	......
2552	Imperial. Kelly & Corcoran, Penn Yan.	1.00	.54	98.46	......
769	Kaiser. Wm. Johnson, Jr., Estate, Chateaugay.	81.14	1.04	17.82	......
2661	Kaiser. John T. Knapp, Davenport Centre.	F .55 L .50	.60	88.37	10.48 11.00
1589	New York State. A. E. Ford & Son, Oneonta.	1.68	.43	97.89	......
2284	Onondaga Choice. Brace, Eaton & Brace, Jordan.	1.06	.74	98.20	......
P 154	Pan American. F. W. Miller Hardware Co., Sherman.	1.84	.80	97.36	......
P 157	Pearl. Jay E. Crandall, Ripley.	.51	1.27	98.22	......
2866	Pine Tree. C. H. Coward & Co., South Byron.	F .22 L .25	.58	98.71	.49 .25
1811	Pine Tree. Craver-Dickinson Seed Co., Binghamton.	2.77	.25	96.98	......
2231	Pine Tree. Ketchum & Maloy, Clyde.	F .55 L	.52	98.73	.20 .50
768	Reclaimed. Stacy & Maloney, Canton.	F .82 L .40	.67	90.26	8.25 6.64
2652	Reliable. Maywood Feed Co., Sidney Centre.	1.91	.40	97.69	......
725	Reliable. Soul Milling Co., Salamanca.	7.03	.33	92.64	......
2875	Reliable. W. F. Sullivan, Silver Springs.	3.31	1.26	95.43	......
719	Squag. Jamestown Electric Mills, Jamestown.	3.72	.37	95.91	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALSIKE CLOVER (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2855	Gandy's Standard "A"................	*F .15	.70	96.59	2.56
	D. G. Fraser, Batavia.	*L.....	....	98.75	2.52
727	Tola................................ H. W. True, Cattaraugus.	1.00	1.51	97.49	......
2381	Value............................... Austin & Rowley, Medina.	1.70	1.41	96.89	......
2221	Value...............................	F 2.04	1.15	96.81	......
	Clyde Farmers Exchange, Clyde.	L	....	99.50	......
P 155	Vicar............................... N. R. Saxton, Kennedy.	.46	.52	99.02	......
	BLUE GRASS:				
1848	Canadian............................ E. W. Conklin & Son, Inc., Binghamton.	2.38	20.82	76.80	......
1840	Canadian............................ Craver-Dickinson Seed Co., Binghamton.	5.43	12.46	82.11	......
2897	Canadian............................ Harvey Seed Co., Buffalo.	5.32	31.06	63.62	......
721	Canadian............................ Jamestown Electric Mills, Jamestown.	4.88	16.96	78.16	......
2711	Canadian............................ Stumpp & Walter Co., New York.	1.36	19.39	79.25	......
2716	Canadian............................ J. M. Thorburn & Co., New York.	1.95	11.90	86.15	......
2206	Kentucky............................ Brewster, Crittenden Co., Rochester.	2.97	19.50	77.53	......
P 159	Kentucky............................ J. A. Dunham & Son, Brocton.	.56	19.81	79.63	......
2276	Kentucky............................ Frank D. Fish, Ithaca.	.15	12.83	87.02	......
2707	Kentucky............................ Peter Henderson & Co., New York.	.77	21.07	78.16	......
712	Kentucky............................ A. G. Johnson, Jamestown.	2.78	16.50	80.72	......
2279	Kentucky............................ Matteson & Barnes, Ithaca.	1.20	26.48	72.32	......
2402	Kentucky, Eclipse Fancy Cleaned........ William M. Pellet, Watkins.	.90	20.86	78.24	......
2674	Kentucky............................ James K. & Samuel F. Penfield, Delhi.	.56	25.72	73.72	......
1883	Kentucky............................ Daniel J. Ramsey & Son, Auburn.	.45	28.50	71.05	......
1835	Kentucky............................ The Standard Seed Co., Inc., Binghamton.	1.70	28.68	69.62	......

* F and L stand, respectively, for Found and Labeled.

Table II.— Analyses of Samples of Seeds Collected (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	BLUE GRASS (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2831	Kentucky Stemple & Smith, Fort Plain.	.91	13.75	85.34	......
2709	Kentucky Stumpp & Walter Co., New York.	*F .33 *L	12.16	87.51 80.00	....
1715	Kentucky J. M. Thorburn & Co., New York.	.31	4.95	94.74	......
2809	Kentucky Fancy Mrs. Annette E. Bellinger, Canajoharie.	.85	16.00	83.15	......
1849	Kentucky Fancy E. W. Conklin & Son, Inc., Binghamton.	.78	20.16	79.06	......
2898	Kentucky Fancy Harvey Seed Co., Buffalo.	.44	20.17	79.39	......
P 106	Kentucky Fancy Morris Brothers, Oneonta.	.63	16.79	82.58	......
1841	Kentucky Heavy Craver-Dickinson Seed Co., Binghamton.	1.21	11.90	86.89	......
	CRIMSON CLOVER:				
1845	Crimson Clover Craver-Dickinson Seed Co., Binghamton.	.86	1.89	97.25	......
2392	Crimson Clover A. G. Criswell, Medina.	.42	1.88	97.70	......
2702	Crimson Clover Peter Henderson & Co., New York.	.11	.97	98.92	......
	RED CLOVER:				
2669	Red Clover Chas. H. Borden & Jas. F. Elliott, Sidney.	2.57	1.85	95.58	......
2701	Red Clover Peter Henderson & Co., New York.	.45	.15	99.40	......
1570	Red Clover Stevens & Converse, Cooperstown.	.95	.63	98.42	......
2280	Fancy Lawren F. Noxon, Ithaca.	.08	.09	99.83	......
706	Mammoth O. W. Clark & Son, Buffalo.	.60	.34	99.06	......
1860	Mammoth Cole-Leggett Hardware Co., Baldwinsville.	.28	.57	99.15	......
2218	Mammoth Philip Deuchler & Son, Lyons.	F .70 L	.36	98.94 99.58	....
1863	Mammoth John Dix, Skaneateles.	1.02	1.45	97.53	......
2560	Mammoth Dorchester & Rose, Geneva.	.55	.54	98.91	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2253	Mammoth Fred H. Ebeling, Syracuse.	1.13	.08	98.79	......
2668	Mammoth Samuel Harley, Grand Gorge.	1.09	.76	98.15	......
2860	Mammoth W. G. Hill, Attica.	*F 1.42 *L 1.62	.32 1.47	98.26 96.91	....
2408	Mammoth Stephen Hollands & Sons, Hornell.	.49	.54	98.97	......
2398	Mammoth A. G. Johnson, Jamestown.	1.51	1.33	97.16	......
1600	Mammoth Morris Brothers, Oneonta.	2.77	.69	96.54	......
2591	Mammoth Geo. W. Peck Co., Cohocton.	.75	.09	99.16	......
1880	Mammoth Daniel J. Ramsey & Son, Auburn.	.26	.16	99.58	......
1872	Mammoth Smith Bros. Seed Co., Auburn.	.75	.43	98.82	......
2813	Mammoth O. C. Van Evera & Son, Canajoharie.	1.40	.90	97.70	......
2862	Mammoth Fancy B. F. French & Son, Attica.	.50	.86	98.64	......
2554	Mammoth Fancy Kelly & Corcoran, Penn Yan.	.38	.25	99.37	......
749	Mammoth Extra Fancy Scoville, Brown & Co., Wellsville.	.39	.32	99.29	......
1816	Mammoth Growers Guarantee Craver-Dickinson Seed Co., Binghamton.	.25	.34	99.41	......
723	Mammoth Special Soul Milling Co., Salmanca.	2.01	.51	97.48	......
2879	Medium Howard B. Clark, Castile.	.12	.23	99.65	......
2880	Medium Howard B. Clark, Castile.	1.69	.54	97.77	......
705	Medium O. W. Clark & Son, Buffalo.	.76	.29	98.95	......
1859	Medium Cole-Leggett Hardware Co., Baldwinsville.	.31	.22	99.47	......
2242	Medium S. G. Crumpt, Pittsford.	.89	.41	98.70	......
2364	Medium The J. T. Darrison Co., Lockport.	.75	.81	98.44	......
2365	Medium The J. T. Darrison Co., Lockport.	1.61	.44	97.95	......

* F and L stand, respectively, for Found and Labeled.

Table II.— Analyses of Samples of Seeds Collected (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2217	Medium	*F .88	.37	98.75	......
	Philip Deuchler & Son, Lyons.	*L	....	99.60	......
1864	Medium	.64	.56	98.80	......
	John Dix, Skaneateles.				
2254	Medium	1.64	.71	97.65	......
	Fred H. Ebeling, Syracuse.				
1851	Medium	.97	.30	98.73	......
	Edward R. Hayssen & Co., Seneca Falls.				
2861	Medium	F 2.51	.07	97.42	......
	W. G. Hill, Attica.	L 2.48	1.88	95.64	......
2407	Medium	.69	.35	98.96	......
	Stephen Hollands & Son, Hornell.				
2803	Medium	1.44	.34	98.22	......
	John W. Inman, Schuylerville.				
2233	Medium	1.93	.44	97.63	......
	Ketchum & Malloy, Clyde.				
2564	Medium	1.92	1.22	96.86	......
	Marshall-Barrick Co., Lyons.				
2212	Medium	.11	.17	99.72	......
	R. A. Mather, Canandaigua.				
2267	Medium	.88	.48	98.64	......
	Halsey P. Minor, Interlaken.				
P 102	Medium	1.93	.81	97.26	......
	Morris Brothers, Oneonta.				
1946	Medium	1.31	.07	98.62	......
	W. T. Olin, Perry.				
2600	Medium	5.25	.41	94.34	......
	William M. Pellet, Watkins.				
1879	Medium	.47	.10	99.43	......
	Daniel J. Ramsey & Son, Auburn.				
1871	Medium	.93	.31	98.76	......
	Smith Bros. Seed Co., Inc., Auburn.				
2570	Medium	.14	.12	99.74	......
	State Agr'l & Industrial School, Industry.				
2718	Medium	.85	.42	98.73	......
	J. M. Thorburn & Co., New York.				
2814	Medium	1.37	.57	98.06	......
	O. C. Van Evera & Son, Canajoharie.				
2288	Medium	.75	.47	98.78	......
	Fred E. Williams, Marcellus.				
2354	Medium	.98	.79	98.23	......
	Woods & Sprague Milling Co., Albion.				
2371	Medium	.85	.23	98.92	......
	John Young, Lockport.				

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1916.

Number.	KIND OF SEED, BRAND OR TRADE NAME, NAME OF DEALER, AND PLACE OF COLLECTION.	COMPOSITION.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1947	Medium Choice J. J. Martin, Perry.	2.15	.33	97.52	......
2352	Medium Fancy Elmer J. Abbott, Perry.	.26	.22	99.52	......
2555	Medium Fancy Kelly & Corcoran, Penn Yan.	.71	.16	99.13	......
2853	Medium Fancy Special Joseph Meehan, Batavia.	1.76	.35	97.89	......
2223	Medium Fullwerth Clyde Farmers Exchange, Clyde.	1.13	.41	98.46	......
2576	Medium Selected Beekman, Clary & Van Liew, Dundee.	1.13	.70	98.17	......
2882	Medium A B A F. Knoche & Son, Hamburg.	1.31	.71	97.98	......
2245	Medium Ace Bridger & Wilcox, Phelps.	.69	.76	98.55	......
1595	Medium Ace Charles H. Millard, Laurens.	1.10	.68	98.22	......
2396	Medium Ace Frank A. Rinn, Gasport.	1.72	.66	97.62	......
1893	Medium Ace Rhody Toher, Oneida.	.72	.70	98.58	......
2238	Medium Anchor Burr & Starkweather Co., Rochester.	1.03	.15	98.82	......
2869	Medium Anchor Byron Produce Co., Byron.	.98	.10	98.92	......
2567	Medium Arc Ebner & Whaling, Inc., Webster.	1.53	.44	98.03	......
1948	Medium Arc Selected J. J. Martin, Perry.	1.05	.29	98.66	......
P 2	Medium Atlas Charles O. Drake, South Lansing.	1.97	.78	97.25	......
2558	Medium Best Schoonmaker Co., Seneca Falls.	.54	.07	99.39	......
2590	Medium Blue Jay Claude Tucker & Fred Line, Wallace.	.35	.33	99.32	......
1855	Medium Climax Superfine James N. McKeon, Seneca Falls.	1.58	.30	98.12	......
2572	Medium Crown Harry W. Hall, Himrod.	.60	.38	99.02	......
2816	Medium Crown Kurlbaum & Richter, Fonda.	.40	.23	99.37	......
2296	Medium Diamond Burt O. Wilson, Groton.	.06	.04	99.90	......
2377	Medium Elk Eugene O'Byrne, Lockport.	1.18	.19	98.63	......

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2214	Medium Elk......................... Rogers & Sucher, Lyons.	.56	.18	99.26	......
2380	Medium Eureka...................... Le Roy Transfer & Storage Co., Le Roy.	.49	.16	99.35	......
2389	Medium Flag........................ A. G. Criswell, Medina.	.75	.49	98.76	......
2586	Medium Gandy's Extra Fancy No. 10.... Clarence J. Tierney, Wallace.	.84	.58	98.58	......
2561	Medium Gandy's Standard "A" No. 12.. Gipson Meade, Savannah.	2.43	.23	97.34	......
1942	Medium Gandy's Standard Fancy........	*F 2.17	.23	97.50	......
	Bert Beebe, Fredonia, R. F. D.	*L	....	99.00	......
2359	Medium Gandy's Standard "A" Fancy... W. D. Hatch Holley.	1.29	.22	98.49	......
2356	Medium Globe........................ Albion Flour & Grain Co., Albion.	.46	.45	99.09	......
1814	Medium Globe........................ Craver-Dickinson Seed Co., Binghamton.	.21	.64	99.15	......
2219	Medium Globe........................ Philip Deuchler & Son, Lyons.	.31	.15	99.54	......
1898	Medium Globe........................ Benjamin F. Metcalf & Son, Syracuse.	.29	.38	99.33	......
2592	Medium Green........................ William H. Clark & Co., Cohocton.	.71	.81	98.48	......
2225	Medium Honor Selected................ Clyde Farmers Exchange, Clyde.	.19	.20	99.61	......
2856	Medium Honor Selected................ Miller Bros. & Co., Bergen.	.15	.11	99.74	......
2268	Medium I X L........................ Halsey P. Minor, Interlaken.	.11	.06	99.83	......
2387	Medium Keg.......................... S. P. Blood & Co., Medina.	.39	.43	99.18	......
2566	Medium Keg.......................... C. A. Sessions & Son, Palmyra.	.73	.12	99.15	......
2208	Medium Lion......................... Brewster Crittenden Co., Rochester.	.84	.54	98.62	......
2870	Medium Lion......................... Wm. Watson & Son, Warsaw.	1.22	.54	98.24	......
2286	Medium Onondaga Choice Recleaned..... Brace, Eaton & Brace, Jordan.	.71	.07	99.22	......
2226	Medium Onondaga Recleaned........... Clyde Farmers Exchange, Clyde.	.74	.04	99.22	......
1874	Medium Pan American................. Auburn Flour & Feed Co., Auburn.	.61	.60	98.79	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2852	Medium Pan American. Joseph Meehan, Batavia.	1.83	.80	97.37	......
2236	Medium Pan American. H. O. Young & Sons, Palmyra.	.94	.68	98.38	......
2293	Medium Paragon. Scipio Patrons Supply Co., Merrifield.	.74	.78	98.48	......
P 158	Medium Pearl. Jay E. Crandall, Ripley.	.54	.34	99.12	......
2265	Medium Pilot. William H. Excell, Hayt Corners.	1.09	.70	98.21	......
2595	Medium Pilot. Wilder Bros., Painted Post.	.92	.42	98.66	......
2244	Medium Pine Tree. Bridger & Wilcox, Phelps.	.71	.21	99.08	......
1815	Medium Pine Tree. Craver-Dickinson Seed Co., Binghamton.	.26	1.11	98.63	......
1944	Medium Pine Tree. Roche Cash Store, Perry.	.78	.43	98.79	......
2399	Medium Planet.	*F 1.42	1.19	97.39	......
	A. G. Johnson, Jamestown.	*L	....	99.00	......
1852	Medium Reliable. Edward R. Hayssen & Co., Seneca Falls.	.38	.43	99.19	......
724	Medium Reliable. Soul Milling Co., Salmanca.	3.56	.79	95.65	......
2874	Medium Reliable. W. F. Sullivan, Silver Springs.	.97	1.35	97.68	......
2388	Medium Solar.	F .74	.46	98.80	......
	Chase & Breed, Medina.	L	....	99.55	......
P 7	Medium Star. Charles N. Dietel, Fair Haven.	2.09	.90	97.01	......
737	Medium Star Bulked. C. E. Haines, Fillmore.	1.40	.67	97.93	......
2382	Medium Value.	F .87	.37	98.76	......
	Austin & Rowley, Medina.	L	....	99.35	......
2224	Medium Value.	F .73	.53	98.74	......
	Clyde Farmers Exchange, Clyde.	L	....	99.40	......
2892	Medium XX Choice.	F 2.40	1.28	89.71	6.61
	G. J. & A. L. Mentley, Gowanda.	L	1.12	97.50	2.50
2754	Arc Selected. C. E. Reese, Altmar.	.48	.26	99.26	......
1846	Atlas. E. W. Conklin & Son, Inc., Binghamton.	2.03	1.69	96.28	......
714	Climax. Jamestown Electric Mills, Jamestown.	.42	.24	99.34	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
715	Eclipse Jamestown Electric Mills, Jamestown.	.86	1.01	98.13	......
2282	Eureka Alexander J. Nicht, Auburn.	.71	.26	99.03	......
2804	Flag Fred C. McRae & Co., Schuylerville.	1.03	.59	98.38	......
2827	French Mohawk Valley Co-Op. Co., Fort Plain.	2.90	.90	96.20	......
1574	Giant George L. Dana, Cobleskill.	.91	.51	98.58	......
2553	Giant Kelly & Corcoran, Penn Yan.	1.01	.25	98.74	......
2801	Gilt Edge H. W. Gordinier Sons & Co., Troy.	.25	.17	99.58	......
2275	Grand Champion The Biggs Company, Trumansburg.	*F 1.19 *L	.17	98.64 99.50	....
2867	Hat C. H. Coward & Co., South Byron.	1.71	.57	97.72	......
1594	Hat Charles H. Millard, Laurens.	.94	.79	98.27	......
2278	Honor Selected John P. Matteson & Amos A. Barnes, Ithaca.	.12	.12	99.76	
2826	Keg Charles Z. Brandow & Co., Fort Plain.	.84	.30	98.86	......
1361	Keg Arthur Hill & Co., Amsterdam.	.58	.25	99.17	......
2821	Large A. A. Jacob Allter Estate, St. Johnsville.	.33	.29	99.38	......
2667	Large Samuel Harley, Grand Gorge.	1.50	1.04	97.46	......
2660	Large John T. Knapp, Davenport Centre.	.91	.21	98.88	......
1899	Large Benj. F. Metcalf & Son, Syracuse.	.87	.34	98.79	......
2654	Oriole John E. Cassidy, East Branch.	.12	.12	99.76	......
1831	Paragon E. W. Conklin & Son, Inc., Binghamton.	.59	.58	98.83	......
730	Pea Vine L. Y. Miller & Sons, Olean.	.40	.06	99.54	......
742	Pea Vine May Frank H. Graham, Friendship.	1.17	.66	98.17	......
2283	Puritan Swartout & Shaver, Auburn.	.93	.65	98.42	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2819	Reliable Selected Chris. Fox, St. Johnsville.	1.13	1.10	97.77	......
2651	Reliable Selected Maywood Feed Co., Sidney Centre.	.68	.90	98.42	......
2858	Superior Selected Miller Bros. & Co., Bergen.	.17	.29	99.54	......
2274	Sweepstakes The Biggs Company, Trumansburg.	.95	.27	98.78	......
728	Mammoth A B A H. W. True, Cattaraugus.	.83	.30	98.87	......
1813	Mammoth Ace Craver Dickinson Seed Co., Binghamton.	1.05	1.30	97.65	......
1801	Mammoth Ace I. S. Matthews' Sons, Binghamton.	.55	.27	99.18	......
1578	Mammoth Ace Stewart C. Millard, Otego.	1.08	.76	98.16	......
1892	Mammoth Ace Rhody Toher, Oneida.	2.54	.51	96.95	......
2588	Mammoth Anchor Claude Tucker & Fred Line, Wallace.	1.50	.38	98.12	......
P 108	Mammoth Arc Selected Kirby & Root, Cooperstown.	.25	.40	99.35	......
2886	Mammoth Arc Selected Joseph Theil, North Collins.	.50	.29	99.21	......
2300	Mammoth Atlas Charles O. Drake, South Lansing.	2.43	.59	96.98	......
2589	Mammoth Blue Jay Tucker & Line, Wallace.	.26	.25	99.49	......
2817	Mammoth Crown Kurlbaum & Richter, Fonda.	.50	.34	99.16	......
1582	Mammoth Crown Frank M. Tyson, Unadilla.	.61	.20	99.19	......
2297	Mammoth Diamond Burt O. Wilson, Groton.	.19	.53	99.28	......
P 151	Mammoth Elk Griggs & Ball Co., East Aurora.	.42	.50	99.08	......
2361	Mammoth Gandy's Standard "A" Fancy W. D. Hatch, Holley.	.50	.21	99.29	......
2872	Mammoth Globe Ballintine Hardware Co., Warsaw.	.26	.39	99.35	......
2593	Mammoth Green William H. Clark & Co., Cohocton.	.70	.29	99.01	......
2665	Mammoth Honor Selected Hanford Bros., East Meredith.	.48	.47	99.05	......

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2824	Mammoth I. X. L. Chas. Z. Brandow & Co., Fort Plain.	.26	.06	99.68	......
1830	Mammoth I. X. L. E. W. Conklin & Son, Inc., Binghamton.	.08	.30	99.62	......
2294	Mammoth I. X. L. Thomas W. Ward & Son, Moravia.	.24	.07	99.69	......
2207	Mammoth Lion. Brewster Crittenden Co., Rochester.	.58	.75	98.67	......
1590	Mammoth New York State. A. E. Ford & Son, Oneonta.	1.37	.89	97.74	......
2287	Mammoth Over Run. Frederick E. Williams, Marcellus.	.49	.34	99.17	......
2657	Mammoth Pan American. Cornell & Decker, Stamford.	2.70	1.40	95.90	......
1596	Mammoth Pan American. Elmore Milling Co., Oneonta.	1.94	.80	97.26	......
2587	Mammoth Paragon. Clarence J. Tierney, Wallace.	1.25	1.04	97.71	......
748	Mammoth Fancy Pea Vine. Scoville Brown & Co., Wellsville.	.20	.01	99.79	......
2596	Mammoth Pilot. Wilder Bros., Painted Post.	1.04	.51	98.45	......
1817	Mammoth Pine Tree. Craver-Dickinson Seed Co., Binghamton.	.56	.65	98.79	......
2373	Mammoth Planet. James O. Rignel Co., Inc., Lockport.	*F .66	.31	99.03	......
		*L	....	99.00	......
2659	Mammoth Pyramid. John T. Knapp, Davenport Centre.	1.11	1.22	97.67	......
2876	Mammoth Reliable. J. E. Chaffee, Castile.	1.39	.81	97.80	......
743	Mammoth Star. The Kneifel Grocery Co., Friendship.	.70	.57	98.73	......
2383	Mammoth Value. Austin & Rowley, Medina.	F .91	.76	98.33	......
		L	....	99.30	......
2893	Mammoth "XX". G. J. & A. L. Mentley, Gowanda.	F 1.39	1.17	96.30	1.14
		L	....	....	2.50
	WHITE CLOVER:				
2704	White Clover. Peter Henderson & Co., New York.	.23	.30	99.47	......
734	White Clover. N. Y. Miller & Sons, Olean.	2.07	.41	97.52	......
P 105	White Clover. Morris Brothers, Oneonta.	2.32	.30	97.38	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	WHITE CLOVER (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1847	Choice .... E. W. Conklin & Son, Inc., Binghamton.	2.67	.45	96.88	......
2713	Dutch .... Stumpp & Walter Co., New York.	*F 5.36 *L	.43	94.21 90.00	....
2899	Fancy .... Harvey Seed Co., Buffalo.	17.87	.95	81.18	......
740	Fancy .... Phelps & Sibley Co., Cuba.	2.41	.63	96.96	......
708	Planet .... A. G. Johnson, Jamestown.	4.10	.67	95.23	......
	ORCHARD GRASS:				
2577	Orchard Grass .... Beekman, Clary & Van Liew, Dundee.	1.87	23.57	74.56	......
711	Orchard Grass .... A. G. Johnson, Jamestown.	.66	28.89	70.45	......
2888	Orchard Grass .... Law & Wilber, Collins.	2.27	22.07	75.66	......
P 107	Orchard Grass .... Morris Brothers, Oneonta.	1.50	22.46	76.04	......
2810	Choice .... Mrs. Annette E. Bellinger, Canajoharie.	1.10	27.12	71.78	......
2673	Choice .... Borden & Elliott, Sidney.	.77	28.97	70.26	......
2401	Climax Superfine .... William M. Pellet, Watkins.	8.00	26.73	65.27	......
2822	Fancy .... Chas. Z. Brandow & Co., Fort Plain.	.74	26.38	72.88	......
	RAPE:				
2579	Dwarf Essex .... C. J. Bigelow & Co., Dundee.	.14	.13	99.73	......
2719	Dwarf Essex .... A. T. Boddington & Co., Inc., New York.	.03	.13	99.84	......
1844	Dwarf Essex .... Craver-Dickinson Seed Co., Binghamton.	.03	.23	99.74	......
2394	Dwarf Essex .... A. G. Criswell, Medina.	Trace	.36	99.64	......
2896	Dwarf Essex .... Harvey Seed Co., Buffalo.	None	.30	99.70	......
P 8	Dwarf Essex .... Oliver William Hill, McDougall.	.06	.27	99.67	......
747	Dwarf Essex .... Scoville Brown & Co., Wellsville.	.02	.33	99.65	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RAPE (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1837	Dwarf Essex The Standard Seed Co., Inc., Binghamton.	Trace	.15	99.85	......
	RED TOP:				
2670	Red Top Borden & Elliott, Sidney.	1.80	6.20	92.00	......
2277	Red Top Frank D. Fish, Ithaca.	*F 8.50 *L11.70	15.82	63.48	12.20 9.50
709	Red Top A. G. Johnson, Jamestown.	.83	2.37	96.80	......
2393	Ace Fancy A. G. Criswell, Medina.	1.12	6.98	91.90	......
1576	Ace George L. Dana, Cobleskill.	.99	6.18	92.83	......
2832	Ace Stemple & Smith, Fort Plain.	1.11	10.00	88.89	......
1588	Ace William R. Jenkins, Schenevus.	1.37	8.74	89.89	......
1885	Ace Daniel J. Ramsey & Son, Auburn.	1.20	7.13	91.67	......
1884	Baxter Daniel J. Ramsey & Son, Auburn.	2.10	8.23	89.67	......
1861	Blue Jay Cole-Leggett Hardware Co., Baldwinsville.	.85	7.10	92.05	......
2663	Choice Hanford Bros., East Meredith.	1.56	6.70	91.74	......
716	Climax Jamestown Electric Mills, Jamestown.	1.77	5.89	92.34	......
2598	Climax Superfine William H. Pellet, Watkins.	1.72	11.02	87.26	......
2720	Fancy A. T. Boddington & Co., Inc., New York.	1.56	12.41	86.03	......
2205	Fancy Brewster Crittenden Co., Rochester.	1.20	5.75	93.05	......
P 160	Fancy Card Seed Co., Fredonia.	6.00	8.71	85.29	......
1825	Fancy No. 1 E. W. Conklin & Son, Inc., Binghamton.	1.65	5.73	92.62	......
2256	Fancy Frederick H. Ebeling, Syracuse.	F .55 L	4.65	94.80 94.79	....
2662	Fancy Hanford Bros., East Meredith.	F 4.22 L 5.80	10.37	79.78	5.63 5.00

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	KIND OF SEED, BRAND OR TRADE NAME, NAME OF DEALER, AND PLACE OF COLLECTION.	COMPOSITION. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	REDTOP (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2706	Fancy. Peter Henderson & Co., New York.	.51	2.85	96.64	......
1363	Fancy. Arthur Hill & Co., Amsterdam.	1.61	8.16	90.23	......
710	Fancy. A. G. Johnson, Jamestown.	1.80	13.43	84.77	......
2259	Fancy. Wilbur M. Jones, Fayetteville.	.81	8.63	90.56	......
2815	Fancy. Kurlbaum & Richter, Fonda.	1.26	6.76	91.98	......
2806	Fancy. Fred C. McRae & Co., Schuylerville.	11.30	11.38	77.32	......
1580	Fancy. Stewart D. Millard, Otego.	22.00	15.53	62.47	......
1581	Fancy. Stewart C. Millard, Otego.	10.97	10.30	78.73	......
P 104	Fancy. Morris Brothers, Oneonta.	1.45	5.55	93.00	......
2895	Fancy. Palmer & Casten, South Dayton.	5.92	8.83	85.25	......
1870	Fancy. Smith Bros. Seed Co., Inc., Auburn.	1.72	7.52	90.76	......
1834	Fancy. The Stanford Seed Co., Inc., Binghamton.	2.00	6.32	91.68	......
1818	Globe. Craver-Dickinson Seed Co., Binghamton.	.25	2.35	97.40	......
2355	Honor. Albion Flour & Feed Co., Albion.	.50	6.58	92.92	......
2823	Imperial. Charles Z. Brandow & Co., Fort Plain.	1.53	6.38	92.09	......
2556	Imperial. Kelly & Corcoran, Penn Yan.	1.95	5.85	92.20	......
772	Onondaga Choice Recleaned. Fred R. Bisnett, Watertown.	1.20	6.80	92.00	......
1886	Unhulled. Daniel J. Ramsey & Son, Auburn.	1.65	35.26	63.09	......
	TIMOTHY:				
745	Timothy. Baker Bros., Andover.	.27	.12	99.61	......
2201	Timothy. Brewster Crittenden Co., Rochester.	.45	.12	99.43	......
1573	Timothy. C. Arthur Bunn, Richmondville.	.27	.17	99.56	......
2878	Timothy. Howard B. Clark, Castile.	.10	.24	99.66	......

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
703	Timothy...... O. W. Clark & Son, Buffalo.	.20	.36	99.44	......
2559	Timothy...... Dorchester & Rose, Geneva.	.19	.50	99.31	......
2894	Timothy...... Dye Bros., South Dayton.	.50	.20	99.30	......
1591	Timothy, A Grade...... A. E. Ford & Son, Oneonta.	.99	.68	98.33	......
1592	Timothy, B Grade...... A. E. Ford & Son, Oneonta.	.53	1.04	98.43	......
2708	Timothy...... Peter Henderson & Co., New York.	.06	.02	99.92	......
773	Timothy...... G. W. Henry & Son, Theresa.	.56	1.15	98.29	......
2406	Timothy...... Stephen Hollands & Sons, Hornell.	.21	.35	99.44	......
2298	Timothy...... Carter Huested, Kings Ferry.	.27	.73	99.00	......
1900	Timothy...... Benjamin F. Metcalf & Son, Syracuse.	*F .25 *L .25	.61 .75	97.73 99.00	1.41 Trace
732	Timothy...... L. Y. Miller & Sons, Olean.	.25	.15	99.60	......
1598	Timothy B...... Morris Brothers, Oneonta	.82	.39	98.79	......
1599	Timothy C...... Morris Brothers, Oneonta.	1.62	.98	97.40	......
1571	Timothy D...... Stevens & Converse, Cooperstown.	.37	.71	98.92	......
2248	Timothy...... Perry C. Shafer Co., Brockport.	.33	.28	99.39	......
2812	Timothy...... O. C. Van Evera & Son, Canajoharie.	.17	1.12	98.71	......
2370	Timothy...... John Young, Lockport.	.23	.53	99.24	......
2243	Ace...... Bridger & Wilcox, Phelps.	.18	.11	99.71	......
1807	Ace...... Craver-Dickinson Seed Co., Binghamton.	.45	.45	99.10	......
2375	Ace...... James O. Rignel Co., Inc., Lockport.	.65	.38	98.97	......
2818	Acme...... Kurlbaum & Richter, Fonda.	F .03 L	.17	99.80 99.80	....
1822	Arrow...... E. W. Conklin & Son, Inc., Binghamton.	.82	.35	98.83	......
2656	Arrow...... Cornell & Decker, Stamford.	.28	.29	99.43	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	Per ct.	Per ct.	Per ct.	Per ct.
2261	Arrow Daniel Quinlan & Son, Jamesville.	.25	.30	99.45	......
2807	Arrow Henry D. Safford, Mechanicville.	.52	.41	99.07	......
770	Arrow J. L. Smithers, Morristown.	.14	.17	99.69	......
2557	Best Schoonmaker Co., Seneca Castle.	.07	.12	99.81	......
2808	Bingo Mrs. Annette E. Bellinger, Canajoharie.	*F Trace *L	.05	99.95 99.95	....
1820	Bingo E. W. Conklin & Son, Inc., Binghamton.	.05	.30	99.65	......
2266	Bingo Halsey P. Minor, Interlaken.	.01	.11	99.88	......
744	Bird Baker Bros., Andover.	.18	.17	99.65	......
1804	Bison Chas. N. Codner, Owego.	1.35	.95	97.70	......
775	Bison Stoddard & Sarvey, Carthage.	1.40	1.06	97.54	......
2833	Bison John J. Tracey, Ballston Spa.	2.11	1.42	96.47	......
2594	Blue Jay William H. Clark & Co., Cohocton.	.08	.16	99.76	......
2362	Bon W. D. Hatch, Holley.	.07	.07	99.86	......
1897	Bon Benjamin F. Metcalf & Son, Syracuse.	.20	.17	99.63	......
2568	Bon The Wooster & Mott Co., Webster.	.19	.22	99.59	......
1827	C & M E. W. Conklin & Son, Inc., Binghamton.	.05	.05	99.90	......
1866	Choice John Dix, Skaneateles.	.72	.22	99.06	......
2859	Choice W. G. Hill, Attica.	F .42 L .67	.24 .48	99.34 98.85	....
2828	Choice Mohawk Valley Co-Op. Co., Fort Plain.	.20	.53	99.27	......
2751	Choice Recleaned Onondaga Chas. Pillmore, Rome.	.02	.10	99.88	......
2581	Churchill's Fancy Kimmel Hardware Co., Wayland.	.34	.36	99.30	......
717	Climax Jamestown Electric Mills, Jamestown.	.25	.67	99.08	......
1854	Climax Superfine James M. McKeon, Seneca Falls.	.26	.17	99.57	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	Per ct.	Per ct.	Per ct.	Per ct.
2403	Climax Superfine William M. Pellet, Watkins.	.37	.23	99.40	......
1805	Colonial Chas. N. Codner, Owego.	.67	.56	98.77	......
1575	Colonial George L. Dana, Cobleskill.	.74	.44	98.82	......
1949	Dandy J. J. Martin, Perry.	.15	.68	99.17	......
2873	Dandy W. F. Sullivan, Silver Springs.	.52	.32	99.16	......
1824	Don E. W. Conklin & Son, Inc., Binghamton.	1.55	1.27	97.18	......
718	Eclipse Jamestown Electric Mills, Jamestown.	.05	.37	99.58	......
2599	Eclipse William M. Pellet, Watkins.	.45	.46	99.09	......
2653	Empire John E. Cassidy, East Branch.	2.63	1.35	96.02	......
2264	Fancy Charles R. Briggs, Apulia.	.76	.22	99.02	......
2865	Fancy B. F. French & Son, Attica.	.45	.55	99.00	......
2565	Fancy Marshall-Barrick Co., Lyons.	.67	.29	99.04	......
1802	Fancy I. S. Matthews' Sons, Binghamton.	.12	.04	99.84	......
2571	Fancy State Agr'l & Industrial School, Industry.	.03	.36	99.61	......
2710	Fancy Stumpp & Walter Co., New York.	.17	.28	99.55	......
1853	Fullworth Edward R. Hayssen Co., Seneca Falls.	.65	.25	99.10	......
1941	Gandy's Fancy Standard "A" Bert Beebe, Fredonia, R. F. D.	*F .16 *L	.44	99.40 99.00	....
2585	Gandy's Fancy Standard "A" Clarence J. Tierney, Wallace.	F .23 L	.52	99.25 99.00	....
2802	Gilt Edge H. W. Gordinier Sons & Co., Troy.	.31	.50	99.19	......
2825	Globe Charles Z. Brandow & Co., Fort Plain.	.02	.06	99.92	......
1808	Globe Bright Hulled Craver-Dickinson Seed Co., Binghamton.	.32	.10	99.58	......
1895	Globe Bright Hulled Charles F. Saul, Syracuse.	.09	.02	99.89	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2891	Gold Medal L. L. Hathaway, Collins.	.07	.25	99.68	......
2334	Gold Medal Judson Snyder, Newark.	.07	.72	99.21	......
2889	Honor Law & Wilber, Collins.	.17	.25	99.58	......
1833	Honor Selected The Stanford Seed Co., Inc., Binghamton.	.05	.19	99.76	......
1597	Imperator Elmore Milling Co., Oneonta.	1.00	.27	98.73	......
2883	Jap F. Knoche & Son, Hamburg.	.24	.19	99.57	......
2752	Jap W. E. Owen & Son, Utica.	.13	.12	99.75	......
1821	King E. W. Conklin & Son, Inc., Binghamton.	.05	.30	99.65	......
2551	King Kelly & Corcoran, Penn Yan.	.15	.28	99.57	......
1869	King Smith Bros. Seed Co., Inc., Auburn.	.20	.37	99.43	......
2227	Liberty Selected Clyde Farmers Exchange, Clyde.	.05	.12	99.83	......
1858	Liberty Selected Cole-Leggett Hardware Co., Baldwinsville.	.65	.27	99.08	......
2390	Liberty Selected A. C. Criswell, Medina.	.48	.13	99.39	......
771	Liberty Selected H. G. Maune & Son, Heuvelton.	.17	.12	99.71	......
2857	Liberty Selected Miller Bros. & Co., Bergen.	.38	.27	99.35	......
1832	Liberty Selected The Stanford Seed Co., Inc., Binghamton.	.40	.39	99.21	......
2405	N. Y. & Pa. Standard Choice William D. Burt, Nunda.	1.15	1.23	97.62	......
1809	N. Y. & Pa. Standard Choice Craver-Dickinson Seed Co., Binghamton.	1.65	.65	97.70	......
P 109	N. Y. & Pa. Standard Wood Brothers, Cooperstown.	1.01	.93	98.06	......
1887	Onondaga Choice Recleaned Buyea & Standt, Oneida.	.36	.42	99.22	......
2397	Oriole John T. Darrison & Co., Lockport.	*F .28 *L	.46	99.26 99.50	....

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 6	Overland. Charles N. Dietel, Fair Haven.	.35	.11	99.54	......
1806	Overrun. B. L. Grant & Son, Cortland.	.32	.10	99.58	......
1867	Pan American. Alexander J. Nicht, Auburn.	.37	.27	99.36	......
2237	Pan American. H. O. Young & Sons, Palmyra.	.18	.18	99.64	......
P 156	Pearl. Jay E. Crandall, Ripley.	.38	.37	99.25	......
746	Peerless. Baker Bros., Andover.	.35	.10	99.55	......
2271	Pine Tree. The Biggs Company, Trumansburg.	.13	.15	99.72	......
2209	Pine Tree. C. W. Ferguson, Elmira.	.15	.25	99.60	......
1593	Pine Tree. A. E. Ford & Son, Oneonta.	.11	.21	99.68	......
1803	Pine Tree. I. S. Matthews' Sons, Binghamton.	.27	.05	99.68	......
1882	Pine Tree. Daniel J. Ramsey & Son, Auburn.	.32	.30	99.38	......
1945	Pine Tree. Roche Cash Store, Perry.	.07	.06	99.87	......
2884	Pioneer. William Bowen, North Collins.	*F .22	.11	99.67	......
		*L	....	99.81	......
2374	Planet. James O. Rignel Co., Inc., Lockport.	F .20	.41	99.39	......
		L	....	99.30	......
1585	Prime. Bert E. McIntosh, Unadilla.	.44	.24	99.32	......
2404	Quaker. Knapp Bros., Elmira.	.36	.26	99.38	......
1881	Ramsey's Special Recleaned. Daniel J. Ramsey & Son, Auburn.	.12	.25	99.63	......
2270	Reliable. Halsey P. Minor, Interlaken.	.87	.40	98.73	......
722	Reliable. Soul Milling Co., Salamanca.	1.05	.25	98.70	......
1823	Rex. E. W. Conklin & Son, Inc., Binghamton.	.85	1.10	98.05	......
774	Seneca. Ambrose Gormley, Carthage.	.82	.42	98.76	......
736	Seneca. C. E. Haines, Fillmore.	.85	.25	98.90	......
2753	Seneca. W. E. Owen & Son, Utica.	.38	.50	99.12	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (concluded):	Per ct.	Per ct.	Per ct.	Per ct.
2241	Sledge S. G. Crump, Pittsford.	.20	.82	98.98	......
P 153	Snow E. E. Godfrey, East Aurora.	.49	.66	98.85	......
2366	Special The J. T. Darrison Co., Lockport.	.22	.55	99.23	......
1586	Square Deal William R. Jenkins, Schenevus.	.88	.54	98.58	......
1890	Square Deal Rhody Toher, Oneida.	.34	.56	99.10	......
1826	Star E. W. Conklin & Son, Inc., Binghamton.	.02	.05	99.93	......
2272	Sweepstakes The Biggs Company, Trumansburg.	.12	.13	99.75	......
2385	Value Austin & Rowley, Medina.	*F .29 *L	.24	99.47 99.63	....
	VETCH:				
1850	Hairy Vetch E. W. Conklin & Son, Inc., Binghamton.	None	.30	99.70	......
1842	Hairy Vetch Craver-Dickinson Seed Co., Binghamton.	.28	.53	99.19	......
1836	Hairy Vetch Domestic The Stanford Seed Co., Inc., Binghamton.	Trace	.36	99.64	......
735	Hairy Vetch L. Y. Miller & Sons, Olean.	Trace	.13	99.87	......
741	Hairy Vetch Phelps & Sibley Co., Cuba.	6.92	2.20	90.88	......
750	Hairy Vetch Scoville Brown & Co., Wellsville.	.43	.02	99.55	......
1843	Spring Vetch Craver-Dickinson Seed Co., Binghamton.	.16	.38	99.46	......
	ALSIKE AND TIMOTHY MIXED:				
2257	Alsike & Timothy Mixed Frederick H. Ebeling, Syracuse.	.12	.19	99.69	......
	TIMOTHY AND ALSIKE MIXED:				
1583	Timothy & Alsike Mixed Bert E. McIntosh, Unadilla.	4.96	5.01	90.03	......
	TIMOTHY AND ALSIKE:				
2658	Timothy & Alsike, Pyramid John T. Knapp, Davenport Centre.	1.68	1.19	97.13	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1916.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Composition. Inert matter.	Composition. Pure seed.	Composition. Crop seed.
	TIMOTHY, ALSIKE CLOVER AND RED CLOVER MIXTURE:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1577	Timothy, Alsike Clover & Red Clover Mixture, Pyramid. Egbert Snyder, East Worcester.	1.85	1.30	96.85	......
	TIMOTHY AND ALSIKE CLOVER:				
2584	Timothy & Alsike Clover, Pyramid. Clarence J. Tierney, Wallace.	1.32	1.25	97.43	......
	Samples collected during 1917.				
	ALFALFA:				
2749	Alfalfa. Peter Henderson & Co., New York.	Trace	.06	99.94	......
P 672	Alfalfa. Henry Neddo, Whitehall.	Trace	.08	99.92	......
2739	Alfalfa. Stumpp & Walter Co., New York.	*F .06	.47	99.47	......
		*L .12	.43	99.45	......
2724	Alfalfa. Wood & Nostrand, Inc., Farmingdale.	.73	.28	98.99	......
P 60	Ace. Craver-Dickinson Seed Co., Binghamton.	.17	.74	99.09	......
P 200	Best. Advance Implement Co., Batavia.	.04	.12	99.84	......
2436	Best. Wooster & Mott Co., Webster.	.05	.03	99.92	......
P 704	Dakota. Vaughan's Seed Store, New York.	.27	.13	99.60	......
2847	Eureka. H. W. Gordinier & Sons Co., Troy.	.03	.19	99.78	......
P 362	Eureka. Daniel L. Ramsey & Son, Auburn.	.07	.07	99.86	......
2441	Eureka. Perry C. Shafer Co., Brockport.	Trace	.12	99.88	......
P 355	Fancy. Brace, Eaton & Brace, Jordan.	.15	.02	99.83	......
2411	Fancy. Brewster Crittenden & Co., Rochester.	Trace	.17	99.83	......
P 17	Fancy. Fred W. Clark, Skaneateles.	.18	.82	99.00	......
P 554	Fancy. T. C. Smyth, Le Roy.	40.75	.14	59.11	......
P 32	Fancy Northern Grown. Buyea & Standt, Oneida.	.06	.17	99.77	.....
P 169	Gandy's Fancy Standard " A ". J. A. Dunham & Son, Brocton.	F .01	Trace	99.99	......
		L	....	99.00	......
P 59	Globe. Craver-Dickinson Seed Co., Binghamton.	.02	.04	99.94	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALFALFA (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2419	Globe Philip Deuchler & Son, Lyons.	.05	.01	99.94	......
P 198	Globe Hickox Rumsey Co., Batavia.	.08	.07	99.85	......
P 658	Globe Parker & Cleveland, Greenwich.	.03	.14	99.83	......
P 34	Globe James E. Roantree, Canastota.	.17	.16	99.67	......
2409	Honor Burr & Starkweather Co., Rochester.	.10	.14	99.76	......
P 24	Honor William J. Hollenbeck, Munnsville.	.01	.23	99.76	......
P 551	Honor Miller Bros. & Co., Bergen.	Trace	.03	99.97	......
P 78	I X L American Grown Fancy E. W. Conklin & Son, Inc., Binghamton.	.04	.01	99.95	......
P 47	I X L American Grown Fancy Lewis H. Hewitt, Tully.	.01	.22	99.77	......
P 651	I X L American Grown Fancy Joseph Lyttle & Son, Greenwich.	.02	.07	99.91	......
P 354	Krop King Benjamin F. Metcalf & Son, Chittenango.	.05	.12	99.83	......
P 58	Pine Tree Craver-Dickinson Seed Co., Binghamton.	.40	.14	99.46	......
P 38	Pine Tree George L. Scheifele, Oneida.	Trace	.16	99.84	......
	BLUE GRASS:				
P 89	Canada Craver-Dickinson Seed Co., Binghamton.	4.31	9.42	86.27	......
2728	Canada Choice J. & T. Adikes, Jamaica.	6.25	29.84	63.91	......
2726	Kentucky George W. Brush, Northport.	.42	15.78	83.80	......
2745	Kentucky Peter Henderson & Co., New York.	.90	15.81	83.29	......
P 42	Kentucky George L. Scheifele, Oneida.	1.85	17.92	80.23	......
P 559	Kentucky Sinclairville Feed Mill, Sinclairville.	1.94	12.54	85.52	......
2743	Kentucky Stumpp & Walter Co., New York.	*F .68 *L 1.03	17.82 15.37	81.50 83.60	....
P 705	Kentucky Vaughan Seed Store, New York.	6.65	22.05	71.30	......
P 83	Kentucky Imperial Extra Fancy E. W. Conklin & Son, Inc., Binghamton.	.31	12.07	87.62	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1917.

Number.	KIND OF SEED, BRAND OR TRADE NAME, NAME OF DEALER, AND PLACE OF COLLECTION.	COMPOSITION.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	BLUE GRASS (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 90	Kentucky Heavy	1.05	17.10	81.85	......
	Craver-Dickinson Seed Co., Binghamton.				
	ALSIKE CLOVER:				
2725	Alsike Clover	1.25	.38	98.37	......
	George W. Brush, Northport.				
P 31	Alsike Clover	*F 3.88	.44	90.98	......
	Buyea & Standt, Oneida.	*L 5.11	....	....	3.76
P 186	Alsike Clover	F .88	.66	90.32	8.14
	Falconer Milling Co., Falconer.	L .60	....	....	7.95
P 112	Alsike Clover	.92	.76	98.32	......
	A. E. Ford & Son, Oneonta.				
2747	Alsike Clover	1.45	.78	97.77	......
	Peter Henderson & Co., New York.				
P 174	Alsike Clover	4.72	.44	94.84	......
	A. G. Johnson, Jamestown.				
P 579	Alsike Clover	1.04	.27	98.69	......
	Riley & Wands Co., Olean.				
2740	Alsike Clover	F 2.64	.35	97.01	......
	Stumpp & Walter Co., New York.	L 3.36	.19	96.45	......
P 655	Alsike Clover	F .75	.03	97.33	1.89
	Trumbull & McGrouty, Greenwich.	L	....	96.36	1.45
P 667	Alsike Clover	5.42	.35	94.23	......
	W. S. Wheeler's Son, Ballston Spa.				
2757	Alsike Clover	8.10	.58	91.32	......
	Willoughby & Howe, Newport.				
P 674	A	F .26	.64	95.74	3.36
	S. K. Griswold, Whitehall.	L .65	2.08	94.59	2.68
P 671	AA	2.16	.42	97.42	......
	Henry Neddo, Whitehall.				
P 57	Ace	11.01	1.17	87.82	......
	Craver-Dickinson Seed Co., Binghamton.				
2426	Ace	F 3.55	1.38	95.07	......
	C. W. Ferguson, Elmira.	L 3.11	....	....	......
P 657	Ace	4.92	.69	94.39	......
	Parker & Cleveland, Greenwich.				
P 39	Ace	F 1.27	.46	94.91	3.36
	George L. Schiefele, Oneida.	L 1.25	....	....	3.00
P 190	Arc	2.96	.54	96.50	......
	Ashville Electric Mills, Ashville.				
P 609	Arc	F 3.38	1.06	95.56	......
	Liberty Coal & Feed Co., Liberty.	L 5.00	....	....	......
P 676	Arc	F 2.38	.83	96.79	......
	Vernon W. Race, Fort Ann.	L 3.00	....	....	......
1305	Arc	F 6.45	.76	92.79	......
	Stoddard & Sarvey, Carthage.	L 5.00	....	....	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALSIKE CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 370	Arc	*F 4.08	.45	95.47	......
	Webster & Gleason, Groton.	*L 5.00	......	......	......
P 114	B	1.89	.16	97.95	......
	Morris Brothers, Oneonta.				
P 578	Best	.73	1.57	97.70	......
	Riley & Wands Co., Olean.				
P 607	C	F 1.81	1.58	87.31	9.30
	C. G. Clark, Westtown.	L 2.50	......	......	11.00
1314	Climax Superfine	2.03	2.01	95.96	......
	G. D. Northridge & Son, Malone.				
2765	Choice C. M.	4.03	.59	95.38	......
	Farney & Steiner, Croghan.				
2842	Choice C. M.	4.01	1.20	94.79	......
	Elbridge M. Snyder, Melrose.				
P 367	Choice C. M.	F .48	.82	94.46	4.24
	Amasa M. Strong, Syracuse.	L .50	......	......	5.25
2758	Choice C. M.	3.62	.53	95.85	......
	F. J. Switzer, Fulton.				
P 565	Eureka	2.43	.52	97.05	......
	Albion Flour & Grain Co., Albion.				
P 363	Eureka	.24	.20	99.56	......
	Swarthout & Shaver, Auburn.				
1310	Fancy	1.34	.65	98.01	......
	C. E. Brush & Son, Moira.				
P 177	Fancy	2.27	.77	96.96	......
	H. R. Wilber Corporation, Jamestown.				
P 184	G	.16	4.17	95.67	......
	O. T. Wiborg, Falconer.				
2417	Gandy's Fancy A	F .51	.34	96.45	2.70
	Dorchester & Rose, Geneva.	L	......	98.75	2.50
P 168	Gandy's Fancy A	F 1.41	.51	93.77	4.31
	J. A. Dunham & Son, Brocton.	L	......	......	2.52
P 604	Gandy's Extra Fancy AA	3.33	.88	95.79	......
	Levi Bedell, Coxsackie.				
P 55	Globe	.79	.31	98.90	......
	Craver-Dickinson Seed Co., Binghamton.				
P 199	Globe	.76	.21	99.03	......
	Hickox Rumsey Co., Batavia.				
P 193	Honor	1.67	.49	97.84	......
	Palmer Milling Co., South Dayton.				
P 364	Honor	1.72	.18	98.10	......
	Swarthout & Shaver, Auburn.				
P 77	Imperial	.21	.24	99.55	......
	E. W. Conklin & Son, Inc., Binghamton.				
P 33	Imperial	2.10	.24	97.66	......
	James E. Roantree, Canastota.				

* F and L stand, respectively, for Found and Labeled.

TABLE II.—ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	ALSIKE CLOVER (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 56	Kaiser	8.00	1.64	90.36	......
	Craver-Dickinson Seed Co., Binghamton.				
1307	No. 203	*F .32	.27	94.64	4.77
	Roy T. Allen, Gouverneur.	*L .29	......	......	3.59
2418	Onondaga Choice Recleaned	3.18	.20	96.62	......
	Philip Deuchler & Son, Lyons.				
P 12	Pan American	2.95	.32	96.73	......
	William H. Flynn, Syracuse.				
P 13	Pine Tree	F 1.51	.52	95.71	2.26
	Fred W. Clark, Skaneateles.	L 1.25	......	......	3.25
P 54	Pine Tree	2.73	.41	96.86	......
	Craver-Dickinson Seed Co., Binghamton.				
2427	Pine Tree	F .70	.22	95.50	3.58
	C. W. Ferguson, Elmira.	L .70	......	......	3.55
P 182	Pine Tree	F 1.53	.52	95.53	2.42
	Jamestown Electric Mills, Jamestown.	L 1.25	......	......	3.25
P 569	Reliable	F 5.34	.36	94.30	......
	Joseph Theil, North Collins.	L 5.00	......	......	......
2850	T. F.	2.69	.21	97.10	......
	H. W. Gordinier & Sons Co., Troy.				
P 568	Tola	3.55	.60	95.85	......
	F. Knoche & Son, Hamburg.				
P 587	Value	1.52	1.00	97.48	......
	A. G. Johnson, Jamestown.				
P 555	Vicar	2.20	.10	97.70	......
	Akron Produce Company, Akron.				
2437	Vicar	.28	.20	99.52	......
	Wooster & Mott Co., Webster.				
	CRIMSON CLOVER:				
2748	Crimson Clover	.52	.06	99.42	......
	Peter Henderson & Co., New York.				
2738	Crimson Clover	F .65	2.21	97.14	......
	Stumpp & Walter Co., New York.	L 1.19	3.98	94.83	......
	RED CLOVER:				
2732	Red Clover	1.96	.77	97.27	......
	J. & T. Adikes, Jamaica.				
2722	Red Clover	.33	.23	99.44	......
	Geo. W. Conklin, Huntington.				
P 558	A B A	.82	1.91	97.27	......
	Sinclairville Feed Mills, Sinclairville.				
P 668	Arc	.62	.11	99.27	......
	W. S. Wheeler's Son, Ballston Spa.				
1312	Climax Superfine	.88	.21	98.91	......
	G. D. Northridge & Son, Malone.				

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
2845	Export H. W. Gordinier & Sons Co., Troy.	.24	.51	99.25	......
P 659	Globe Parker & Cleveland, Greenwich.	.29	.16	99.55	......
P 678	Honor Selected James G. Kinne, Fort Edward.	.39	.19	99.42	......
P 53	Honor Selected The Stanford Seed Co., Binghamton.	.11	.13	99.76	......
1309	Kaiser Hyland & Co., Chateaugay.	1.14	2.90	95.96	......
P 560	Pan American Fred Pfanner, Jr., Tonawanda.	2.33	.39	97.28	......
P 365	Peavine Swarthout & Shaver, Auburn.	.94	.25	98.81	......
P 561	Mammoth John T. Darrison Co., Inc., Lockport.	1.49	.19	98.32	......
2721	Mammoth John Dean, Greenlawn.	2.29	.61	97.10	......
P 111	Mammoth A. E. Ford & Son, Oneonta.	.60	.41	98.99	......
P 171	Mammoth A. G. Johnson, Jamestown.	.45	.39	99.16	......
1304	Mammoth Willard D. Nellis, Watertown.	*F 1.50 *L	.77	97.73 97.50	....
P 580	Mammoth Riley & Wands Co., Olean.	.15	.11	99.74	......
P 366	Mammoth Swarthout & Shaver, Auburn.	.61	.32	99.07	......
P 654	Mammoth AA Trumbull & McGrouty, Greenwich.	1.40	.25	98.35	......
P 63	Mammoth Ace Craver-Dickinson Seed Co., Binghamton.	.83	.60	98.57	......
P 41	Mammoth Ace George L. Scheifele, Oneida.	1.34	.60	98.06	......
P 19	Mammoth Arc Almer H. Dresser, Eaton.	.39	.43	99.18	......
P 74	Mammoth Atlas E. W. Conklin & Son, Inc., Binghamton.	1.24	.49	98.27	......
P 48	Mammoth Crown Lewis H. Hewitt, Tully.	.76	.10	99.14	......
2839	Mammoth Crown Elbridge M. Snyder, Melrose.	.59	.08	99.33	......
2760	Mammoth Crown F. J. Switzer, Fulton.	.44	.17	99.39	......
P 575	Mammoth Elk Harry S. Gray, Springville.	.28	.14	99.58	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 374	Mammoth Eureka Webb J. Greenfield, Moravia.	.24	.15	99.61	......
2439	Mammoth Elk Wooster & Mott Co., Webster.	.46	.33	99.21	......
P 564	Mammoth Eureka Albion Flour & Grain Co., Albion.	1.15	.67	98.18	......
P 15	Mammoth Fancy Fred W. Clark, Skaneateles.	.37	.28	99.35	......
P 179	Mammoth Fancy H. R. Wilber Corporation, Jamestown.	.26	.12	99.62	......
P 192	Mammoth Fullwerth Palmer Milling Co., South Dayton.	.41	.34	99.25	......
P 601	Mammoth Gandy's Extra Fancy No. 10 Levi Bedell, Coxsackie.	.31	.34	99.35	......
P 62	Mammoth Globe Craver-Dickinson Seed Co., Binghamton.	.62	.25	99.13	......
P 369	Mammoth Globe Barnabus A. Dean & Son, Auburn.	.51	.10	99.39	......
P 573	Mammoth Globe L. L. Hathaway, Collins.	.32	.20	99.48	......
2429	Mammoth Honor Selected Beekman, Clary & Van Liew, Dundee.	.57	.20	99.23	......
2844	Mammoth I X L Empire Mill & Coal Co., Schaghticoke.	.12	Trace	99.88	......
P 49	Mammoth I X L Lewis H. Hewitt, Tully.	.10	.08	99.82	......
P 577	Mammoth Lion Riley & Wands Co., Olean.	.76	.15	99.09	......
2421	Mammoth Onondaga Choice Recleaned Philip Deuchler & Son, Lyons.	.38	.19	99.43	......
P 613	Mammoth Pan American William Ruechert, Dunkirk.	1.05	.21	98.74	......
2762	Mammoth Pan American T. H. Young & Co., Mexico.	.69	.27	99.04	......
2764	Mammoth Paragon Farney & Steiner, Croghan.	1.32	.40	98.28	......
P 677	Mammoth Paragon James G. Kinne, Fort Edward.	.93	.18	98.89	......
P 30	Mammoth Peavine Buyea & Standt, Oneida.	1.43	.27	98.30	......
P 25	Mammoth Peavine William J. Hollenbeck, Munnsville.	.35	.08	99.57	......
2428	Mammoth Pine Tree Beekman, Clary & Van Liew, Dundee.	.30	.28	99.42	......
P 61	Mammoth Pine Tree Craver-Dickinson Seed Co., Binghamton.	.31	.09	99.60	......

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 181	Mammoth Pine Tree ... Jamestown Electric Mills, Jamestown.	1.21	.21	98.58	......
P 166	Mammoth Gandy's Standard "A" Fancy.	*F .59	.26	99.15	......
	J. A. Dunham & Son, Brocton.	*L	....	99.00	......
2415	Mammoth Star ... Brewster Crittenden & Co., Rochester.	1.39	.48	98.13	......
P 16	Medium ... Fred W. Clark, Skaneateles.	.23	.27	99.50	......
2750	Medium ... Peter Henderson & Co., New York.	1.09	.76	98.15	......
P 172	Medium ... A. G. Johnson, Jamestown.	.41	.11	99.48	......
P 35	Medium ... Alonzo B. Nichols & Son, Canastota.	.78	.24	98.98	......
P 584	Medium ... Portville Mills, Portville.	.29	.20	99.51	......
P 361	Medium ... Daniel L. Ramsey & Son, Auburn.	.09	.17	99.74	......
2737	Medium ...	F 1.14	.28	98.58	......
	Stumpp & Walter Co., New York.	L 2.39	.90	96.71	......
P 670	Medium A ... Saratoga Milling & Grain Co., Saratoga.	.18	.03	99.79	......
P 64	Medium Ace ... Craver-Dickinson Seed Co., Binghamton.	1.51	.47	98.02	......
P 188	Medium Ace ... Falconer Milling Co., Falconer.	.92	.35	98.73	......
2425	Medium Ace ... C. W. Ferguson, Elmira.	1.16	.58	98.26	......
P 37	Medium Ace ... George L. Scheifele, Oneida.	.80	.31	98.89	......
P 189	Medium Arc Selected ... Ashville Electric Mills, Ashville.	.53	.58	98.89	......
P 20	Medium Arc Selected ... Almer H. Dresser, Eaton.	.21	.13	99.66	......
2841	Medium Atlas ... Elbridge M. Snyder, Melrose.	1.34	.43	98.23	......
P 592	Medium B. B. ... W. D. Hatch, Holley.	.65	.20	99.15	......
P 703	Medium Choice ... Vaughan Seed Store, New York.	.22	.11	99.67	......
P 76	Medium Crown ... E. W. Conklin & Son, Inc., Binghamton.	.72	.57	98.71	......
P 50	Medium Crown ... Lewis H. Hewitt, Tully.	.48	.12	99.40	......
2480	Medium Crown ... Elbridge M. Snyder, Melrose.	.57	.15	99.28	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (continued):	Per ct.	Per ct.	Per ct.	Per ct.
2759	Medium Crown. F. J. Switzer, Fulton.	.47	.18	99.35	......
P 566	Medium Elk. Eugene O'Byrne, Lockport.	.19	.21	99.60	......
2438	Medium Elk. Wooster & Mott Co., Webster.	.19	.08	99.73	......
P 608	Medium Etna. C. G. Clark, Westtown.	*F 2.91 *L 2.90	2.17	92.35	2.57 1.50
P 553	Medium Eureka. Le Roy Transfer & Storage Co., Le Roy.	.42	.07	99.51	......
P 23	Medium Eureka. Edward R. Hayssen Co., Seneca Falls.	.25	.01	99.74	......
2433	Medium Eureka. William Wilson, Geneva.	.81	.49	98.70	......
P 178	Medium Fancy. H. R. Wilber Corporation, Jamestown.	.17	.01	99.82	......
P 360	Medium Fullwerth. Daniel L. Ramsey & Son, Auburn.	1.43	.07	98.50	......
P 605	Medium Gandy's Extra Fancy No. 10. Levi Bedell, Coxsackie.	.11	.15	99.74	......
2416	Medium Gandy's Standard A No. 12 Fancy. Dorchester & Rose, Geneva.	.27	.12	99.61	......
P 167	Medium Gandy's Standard A No. 12 Fancy. J. A. Dunham & Son, Brocton.	.26	.08	99.66	......
P 359	Medium Gandy's Standard Fancy No. 12. Daniel L. Ramsey & Son, Auburn.	.10	.10	99.80	......
P 563	Medium Gem. Woods & Sprague, Albion.	.38	.45	99.17	......
P 67	Medium Globe. Craver-Dickinson Seed Co., Binghamton.	.23	.19	99.58	......
P 368	Medium Globe. Barnabus A. Dean & Son, Auburn.	.40	.22	99.38	......
2420	Medium Globe. Philip Deuchler & Son, Lyons.	.02	.17	99.81	......
P 197	Medium Globe. Hickox Rumsey Co., Batavia.	.26	.10	99.64	......
2431	Medium Honor. Beekman, Clary & Van Liew, Dundee.	.46	.17	99.37	......
P 552	Medium Honor Selected. Miller Bros. & Co., Bergen.	.93	.08	98.99	......
P 75	Medium I. X. L. E. W. Conklin & Son, Inc., Binghamton.	.07	.03	99.90	......
2435	Medium I. X. L. C. L. Crosier & Co., Gorham.	.13	.05	99.82	......
P 351	Medium Krop King. Benjamin F. Metcalf & Son, Chittenango.	1.42	.62	97.96	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.—ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED CLOVER (concluded):	Per ct.	Per ct.	Per ct.	Per ct.
P 65	Medium N. Y. & Pa. Std. Choice........ Craver-Dickinson Seed Co., Binghamton.	1.95	.67	97.38	......
P 673	Medium Oak........................ S. K. Griswold, Whitehall.	.38	.24	99.38	......
P 29	Medium Onondaga Choice Recleaned.... Buyea & Standt, Oneida.	.20	.12	99.68	......
P 162	Medium Pan American................ William Ruechert, Dunkirk.	1.01	.33	98.66	......
2422	Medium Onondaga Choice Recleaned..... Philip Deuchler & Son, Lyons.	.38	.08	99.54	......
P 73	Medium Paragon..................... E. W. Conklin & Son, Inc., Binghamton.	.63	.18	99.19	......
2430	Medium Pine Tree.................... Beekman, Clary & Van Liew, Dundee.	1.30	.25	98.45	......
P 66	Medium Pine Tree.................... Craver-Dickinson Seed Co., Binghamton.	.31	.28	99.41	......
P 180	Medium Pine Tree.................... Jamestown Electric Mills, Jamestown.	.76	.39	98.85	......
P 22	Medium Pine Tree.................... Luckern & Malone, Seneca Falls.	.48	.33	99.19	......
P 589	Medium Purisco...................... A. G. Johnson, Jamestown.	.22	.19	99.59	......
P 570	Medium Reliable...................... Joseph Theil, North Collins.	1.11	.22	98.67	......
2414	Medium Star.......................... Brewster Crittenden & Co., Rochester.	1.57	.65	97.78	......
P 588	Medium Value........................ A. G. Johnson, Jamestown.	.68	.31	99.01	......
2410	Medium XX.......................... Burr & Starkweather Co., Rochester.	.14	.15	99.71	......
	WHITE CLOVER:				
2746	White Clover........................ Peter Henderson & Co., New York.	.58	.18	99.24	......
P 702	White Clover........................ Vaughan's Seed Store, New York.	.92	.26	98.82	......
P 585	B. D................................ L. G. Miller & Sons, Olean.	2.60	.82	96.58	......
2734	Choice.............................. James F. Burke, Glen Cove.	2.94	.63	96.43	......
P 45	Choice.............................. George L. Scheifele, Oneida.	2.75	.72	96.53	......
	ORCHARD GRASS:				
2729	Orchard Grass....................... J. & T. Adikes, Jamaica.	.51	85.44	14.05	......

TABLE II.—ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition. Foreign seed.	Composition. Inert matter.	Composition. Pure seed.	Composition. Crop seed.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
	ORCHARD GRASS (concluded):				
P 574	Orchard Grass........................ L. L. Hathaway, Collins.	3.10	18.63	78.27	......
P 43	Orchard Grass........................ George L. Scheifele, Oneida.	.44	30.48	69.08	......
2741	Orchard Grass........................ Stumpp & Walter Co., New York.	*F .14	26.84	72.00	1.02
		*L 3.55	9.65	86.80	1.57
	RAPE:				
P 80	Dwarf Essex........................ E. W. Conklin & Son, Inc., Binghamton.	.02	.16	99.82	......
P 707	Dwarf Essex........................ Vaughan's Seed Store, New York.	Trace	.05	99.95	......
P 591	Sowing........................ Harvey Seed Co., Buffalo.	.01	.10	99.89	......
	RED TOP:				
2731	Red Top........................ J. & T. Adikes, Jamaica.	.74	14.84	84.42	......
P 603	Red Top........................ Levi Bedell, Coxsackie.	1.76	2.01	96.23	......
P 165	Red Top........................ J. A. Dunham & Son, Brocton.	.16	3.14	96.70	......
P 113	Red Top........................ A. E. Ford & Son, Oneonta.	1.80	7.16	91.04	......
P 660	A........................ F. C. McRae & Co., Schuylerville.	3.77	8.87	87.36	......
P 94	Ace Fancy........................ Craver-Dickinson Seed Co., Binghamton.	2.62	5.13	92.25	......
P 669	Ace Fancy........................ Daniel Eddy & Sons, Saratoga Springs.	1.95	5.56	92.49	......
P 173	Ace........................ A. G. Johnson, Jamestown.	.51	7.97	91.52	......
P 44	Ace........................ George L. Scheifele, Oneida.	.80	5.99	93.21	......
P 653	Choice........................ Hoag & Dunning, Greenwich.	14.93	6.93	78.14	......
P 185	Eureka........................ Falconer Milling Co., Falconer.	.43	3.88	95.69	......
P 666	Eureka........................ W. S. Wheeler's Son, Ballston Spa.	.49	5.86	93.65	......
P 557	Fancy........................ Sinclairville Feed Mill, Sinclairville.	.92	6.89	92.19	......
P 708	Fancy........................ Vaughan's Seed Store, New York.	1.27	4.77	93.96	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.—ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).

Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	RED TOP (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 371	Fancy Albert H. Webster & E. C. Gleason, Groton.	.86	6.97	92.17	......
2727	Fancy Ira M. Young, Riverhead.	1.39	5.75	92.86	......
P 606	Fancy C. G. Clark, Westtown.	*F 2.87 *L 3.00	8.77	84.55	3.81 3.00
2843	Fancy Elbridge M. Snyder, Melrose.	6.30	8.19	85.51	......
P 93	Globe Craver-Dickinson Seed Co., Binghamton.	.44	1.69	97.87	......
P 357	Imperial Fancy Carr-Leggett Hardware Co., Port Byron.	1.72	6.41	91.87	......
P 79	Imperial Fancy E. W. Conklin & Son, Inc., Binghamton.	.38	5.16	94.46	......
P 576	Pan American L. G. Miller & Sons, Olean.	.44	6.36	93.20	......
2849	Tip Top Fancy H. W. Gordinier & Sons Co., Troy.	1.13	8.69	90.18	......
	TIMOTHY:				
2730	Timothy J. & T. Adikes, Jamaica.	.14	.28	99.58	......
2413	Timothy Brewster Crittenden & Co., Rochester.	.19	.12	99.69	......
2412	Timothy Brewster Crittenden & Co., Rochester.	.20	.15	99.65	......
P 69	Timothy E. W. Conklin & Son, Inc., Binghamton.	.27	.36	99.37	......
P 187	Timothy Falconer Milling Co., Falconer.	1.63	1.51	96.86	......
2846	Timothy H. W. Gordinier & Sons Co., Troy.	.07	.17	99.76	......
2744	Timothy Peter Henderson & Co., New York.	.49	.33	99.18	......
2733	Timothy Asa O. Jones, Easthampton.	.19	.12	99.69	......
1308	Timothy B. J. Metcalf & Son, Syracuse.	1.01	.69	98.30	......
2723	Timothy O. S. Sammis Co., Huntington.	1.38	1.16	97.46	......
P 701	Timothy Vaughan's Seed Store, New York.	.24	.16	99.60	......
P 110	A A. E. Ford & Son, Oneonta.	.72	.38	98.90	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 115	A — Morris Brothers, Oneonta.	.32	.40	99.28	......
P 84	Ace — Craver-Dickinson Seed Co., Binghamton.	.36	.21	99.43	......
P 40	Ace — George L. Scheifele, Oneida.	.08	.52	99.40	......
P 71	Acme — E. W. Conklin & Son, Inc., Binghamton.	.14	.11	99.75	......
P 70	Arrow — E. W. Conklin & Son, Inc., Binghamton.	.69	.24	99.07	......
P 26	Arrow — Clark W. Davis, Munnsville.	1.11	.22	98.67	......
P 652	Arrow — Joseph Lyttle & Son, Greenwich.	1.24	.19	98.57	......
P 116	B — Morris Bros., Oneonta.	.40	.90	98.70	......
P 583	Bell — William Keim, Allegany.	.31	.19	99.50	......
2763	Bingo — Farney & Steiner, Croghan.	.09	.12	99.79	......
P 375	Bingo — H. P. Minor, Interlaken.	.09	.12	99.79	......
2837	Bingo — John I. Sewell, Johnsonville.	.13	.06	99.81	......
P 556	Bon — Akron Produce Company, Akron.	.15	.03	99.82	......
1306	Bon — J. E. McAllaster & Son, Gouverneur.	.13	.16	99.71	......
2440	Bon — Wooster & Mott Co., Webster.	.34	.21	99.45	......
P 36	Choice — Alonzo B. Nichols & Son, Canastota.	.50	.52	98.98	......
P 358	Choice — Percy, Carr, Leggett, Inc., Cato.	.38	.13	99.49	......
1313	Climax Superfine — G. D. Northridge & Son, Malone.	.04	.09	99.87	......
P 571	Dandy — C. J. Howard, Gowanda Roller Mills, Gowanda.	.33	.55	99.12	......
P 663	Dandy — C. C. Westcott, Mechanicville.	1.24	.14	98.62	......
P 194	Fancy — Merritt & Co., Batavia.	1.24	.42	98.34	......
2742	Fancy — Stumpp & Walter Co., New York.	.06	.12	99.82	......
P 170	Gandy's Fancy Standard "A" — J. A. Dunham & Son, Brocton.	.32	.50	99.18	......

TABLE II.—ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 602	Gandy's Extra Fancy "AA"............ Levi Bedell, Coxsackie.	.18	.20	99.62	......
P 183	Gandy's "G" Choice.................. O. T. Wibord, Falconer.	1.04	.73	98.23	......
2768	Globe.............................. A. H. Barber, Boonville.	.24	.16	99.60	......
P 85	Globe.............................. Craver-Dickinson Seed Co., Binghamton.	.14	.17	99.69	......
P 191	Globe.............................. Dye Edich & Co., South Dayton.	.12	.01	99.87	......
P 572	Gold Medal......................... L. L. Hathaway, Collins.	.12	.68	99.20	......
P 675	Honor Selected..................... Vernon W. Race, Fort Ann.	.03	.07	99.90	......
P 52	Honor Selected..................... The Stanford Seed Co., Binghamton.	.04	.11	99.85	......
P 175	Honor.............................. H. R. Wilber Corporation, Jamestown.	.13	.14	99.73	......
P 11	Imperator.......................... William H. Flynn, Syracuse.	.32	.62	99.06	......
P 562	Imperator.......................... John Young, Lockport.	1.13	.93	97.94	......
P 567	Jap................................ F. Knoche & Son, Hamburg.	.24	.11	99.65	......
2432	King............................... Beekman, Clary & Van Liew, Dundee.	.24	.20	99.56	......
P 27	King............................... Clark W. Davis, Munnsville.	.42	.17	99.41	......
2838	King............................... Edward O'Neill, Valley Falls.	.41	.14	99.45	......
2836	Liberty Selected................... John L. Bame, Nassau.	.45	.53	99.02	......
1311	Liberty Selected................... C. E. Brush & Son, Moira.	.22	.31	99.47	......
P 21	Liberty Selected................... Almer H. Dresser, Eaton.	.03	.28	99.69	......
2434	Liberty Selected................... Hawkins Hardware Co., Inc., Geneva.	.18	.33	99.49	......
P 51	Liberty Selected................... The Stanford Seed Co., Binghamton.	.22	.23	99.55	......
P 176	Liberty............................ H. R. Wilber Corporation, Jamestown.	.16	.15	99.69	......
P 662	N. Y. & Pa. Std.................... J. W. Inman Co., Schuylerville.	1.13	.61	98.26	......
P 88	N. Y. & Pa. Std. Choice............ Craver-Dickinson Seed Co., Binghamton.	2.32	1.14	96.54	......

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*continued*).
Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (continued):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 86	N. Y. & Pa. Std. Prime .... Craver-Dickinson Seed Co., Binghamton.	1.26	.59	98.15	......
P 28	Onondaga Choice Recleaned............ Buyea & Standt, Oneida.	.60	.20	99.20	......
P 68	Onondaga Choice Recleaned............ E. N. Dexter & Co., Inc., Morrisville.	.26	.31	99.43	......
P 373	Pan American........................ Webb J. Greenfield, Moravia.	.20	.16	99.64	......
P 161	Pan American........................ William Ruechert, Dunkirk.	.43	.26	99.31	......
2442	Pan American........................ Perry C. Shafer Co., Brockport.	1.29	.21	98.50	......
P 665	Pan American .... W. S. Wheeler's Son, Ballston Spa.	.51	.45	99.04	......
2761	Pan American........................ T. H. Young & Co., Mexico.	.18	.34	99.48	......
P 164	Pine Tree............................ Card Seed Co., Fredonia.	.13	.12	99.75	......
P 14	Pine Tree............................ Fred W. Clark, Skaneateles.	.23	.17	99.60	......
P 87	Pine Tree............................ Craver-Dickinson Seed Co., Binghamton.	.27	.21	99.52	......
2424	Pine Tree............................ C. W. Ferguson, Elmira.	.16	.12	99.72	......
P 353	Pine Tree............................ Benjamin F. Metcalf & Son, Chittenango.	.10	.16	99.74	......
P 656	Pine Tree............................ Parker & Cleveland, Greenwich.	.09	.12	99.79	......
2755	Pine Tree............................ C. H. Payne, Stittville.	.23	.19	99.58	......
2766	Prime................................ A. H. Barber, Boonville.	1.00	.82	98.18	......
P 582	Purisco.............................. Riley & Wands Co., Olean.	.24	.51	99.25	......
P 586	Quality Fancy........................ The H. R. Wilber Corporation, Jamestown.	.27	.10	99.63	......
P 18	Ramsey's Special..................... Fred W. Clark, Skaneateles.	*F .36 *L	.58	99.06 99.50	....
P 72	Rex.................................. E. W. Conklin & Son, Inc., Binghamton.	1.06	.76	98.18	......
P 664	Square Deal.......................... Lyman Smith & Co., Stillwater.	.03	.52	99.45	......
P 46	Square Deal.......................... Rhody Toher, Oneida.	.34	.60	99.06	......

* F and L stand, respectively, for Found and Labeled.

TABLE II.— ANALYSES OF SAMPLES OF SEEDS COLLECTED (*concluded*).

Samples collected during 1917.

Number.	Kind of Seed, Brand or Trade Name, Name of Dealer, and Place of Collection.	Composition.			
		Foreign seed.	Inert matter.	Pure seed.	Crop seed.
	TIMOTHY (concluded):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
P 82	State E. W. Conklin & Son, Inc., Binghamton.	.22	.48	99.30	......
2756	State Willoughby & Howe, Newport.	.27	.22	99.51	......
P 352	Union Benjamin F. Metcalf & Son, Chittenango.	.50	.26	99.24	......
	VETCH:				
P 81	Hairy Vetch E. W. Conklin & Son, Inc., Binghamton.	Trace	.09	99.91	......
P 92	Hairy Vetch Craver-Dickinson Seed Co., Binghamton.	.12	.03	99.85	......
P 593	Hairy Vetch Gates Milling Co., Lyndonville.	.53	.10	99.37	......
P 590	Hairy Vetch Harvey Seed Co., Buffalo.	Trace	.01	99.99	......
2736	Hairy Vetch I. L. Radwaner, New York.	2.63	.11	97.26	......
P 706	Hairy Vetch Vaughan's Seed Store, New York.	.06	Trace	99.94	......
P 91	Spring Vetch Craver-Dickinson Seed Co., Binghamton.	Trace	.19	99.81	......
2735	Spring Vetch I. L. Radwaner, New York.	.31	Trace	99.69	......
	TIMOTHY AND ALSIKE MIXTURE:				
2423	Timothy & Alsike Mixture Merton Baldwin, Wellsburg.	*F 3.41 *L 4.50	4.44	89.29	2.86 3.50

* F and L stand, respectively, for Found and Labeled.

II. VOLUNTARY EXAMINATIONS FOR CORRESPONDENTS, 1916–1917.

During the past two years 1,251 samples of seeds have been received from correspondents and analyzed for purity. Of these samples, 775 were received during 1916, and 476 during 1917. Since 1914 the number of samples analyzed for correspondents has decreased markedly. This is due to the policy recently followed by the Station, namely, of declining to test seeds for seed dealers. The policy to be applied to the examination of seeds for corre-

spondents is as follows: (1) The sample submitted must bear evidence of being sent by the prospective sower of the seed; (2) it must be of sufficient size and otherwise suitable for a dependable analysis; and, (3) there should be evidence that an analysis would be of real value to the sender. The Station cannot afford to waste time on useless or unnecessary analyses. Neither can it undertake commercial seed testing.

Under this policy, the number of samples examined has greatly decreased during the past two years; yet it is believed that the benefits derived from the seed laboratory have increased, because the number of farmers making use of the service has increased and more worth-while analyses have been made than formerly.

The enforcement of the seed law, discussed elsewhere in this bulletin, has caused an increase in the amount of labeled seeds upon the market. As a rule, these labeled lots of seed are put out by reputable seed dealers whose brand name or purity-test tag serves as a guarantee of the seeds offered. Farmers in increasing numbers are taking advantage of these offerings and feel that further tests of them for purity are unnecessary, especially in the case of brands which experience has demonstrated to be satisfactory.

The seed trade conditions of the past two seasons are set forth in a general way in the following tabular statement:

TABLE III.—DATA ON FARMERS' SEED SAMPLES ANALYZED DURING 1916-1917.

Kind of Seed	Percentage of samples containing dodder.		Percentage of samples containing noxious weed seeds.		Total number of samples analyzed.	
	1916	1917	1916	1917	1916	1917
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Alsike clover	0.9	.....	54.2	75.8	210	149
Red clover	7.5	1.9	75.1	80.0	205	108
Alfalfa	7.1	3.5	22.5	10.6	173	86
Timothy	.....	.....	19.6	31.4	107	57
Alsike-timothy mixture	.....	.....	50.0	81.2	38	32
Miscellaneous	.....	.....	33.3	34.0	42	44

This table sets forth clearly the fact that a comparatively high percentage of the samples analyzed contained seeds of one or more of the seven weeds listed as being noxious in this State.[1] The information furnished by these analyses should be of decided value to the sower of such seeds. The noxious-weed content of a number of these samples was of such a character and so large as to make the seed unsafe or even valueless for seeding purposes.

The samples received from this source are those about which special information is desired, and probably do not represent the average run of seeds purchased for sowing, yet they plainly emphasize the great need of proper labeling of all seed offerings.

As usual, seeds of dodder were found in a large number of alfalfa and red clover samples; also in a few of the alsike clover samples examined in 1916. During the past three seasons an average of 7 per ct. of the alfalfa and over 4 per ct. of the red clover seed samples have contained dodder seeds. Some of these lots of seed containing dodder were shipped into this State from adjoining States where there are laws which require a label statement to the effect that such seeds contain dodder.

CONCLUSION.

The conclusion to be drawn from the past season's work in the voluntary examination of samples of seeds for farmers is that there is much impure seed upon New York markets. In the absence of a law which requires the labeling of all lots of seeds offered for sale for seeding purposes, every purchaser of seeds must, to a great extent, look out for himself. Some reputable seedsmen and seed dealers are offering the very best seeds obtainable. Apparently, other dealers do not know and do not care very much what they sell. Some reputable seedsmen and seed dealers have branded and labeled their offerings for a number of years; others are now doing so in compliance with the request of the United States Department of Agriculture that the seed trade furnish uniform label information with all lots of field seeds as a part of the war-emergency plan. Since good crops (food) cannot be produced without pure and viable seeds every purchaser of seeds should, as a part of his responsi-

[1] The following weeds have been listed as being noxious in this State: Canada thistle, chicory, curled dock, dodder, buckhorn plantain, mustard, ox-eye daisy, and wild carrot.

bility, insist upon a guarantee or label upon the seeds he purchases or else test them, himself, for purity and germination. The Government has suggested to the seed trade that uniform label information be furnished with all field crop seeds sold in quantities of ten pounds or more as follows: (1) Name of seedsman; (2) kind of seed; (3) proportion of pure, live seed present, with the month and year of germination test; and (4) country and locality of origin in the case of certain imported seeds. Purchasers of seeds can reasonably insist upon receiving this information and dealers should be prepared to furnish it as part of their effort to increase the nation's crop production. Farmers should be as careful in buying seeds from other farmers as from seed dealers. Very frequently the seedman's seeds have been carefully cleaned, whereas the farmers' seeds are often loaded with many weed seeds and much inert matter which might be, and should be, removed before sowing.

THE VELVET-STEMMED COLLYBIA — A WILD WINTER MUSHROOM.*

F. C. STEWART.

SUMMARY.

The velvet-stemmed Collybia, or winter mushroom, is a common wild mushroom which should be better known and more generally used for food. It has a reddish yellow cap, white gills and velvety, brown stem. It grows in dense clusters on stumps, logs and buried wood. Its principal season is October, November and May but it may be found, also, in spells of mild weather during winter. The caps may freeze and thaw several times without injury.

In flavor and consistency it is excellent. The viscidity of the caps, which makes them disagreeable to handle and difficult to clean, is the most objectionable feature of the fungus. The caps possess a remarkable capacity for the absorption of water. In the presence of moisture shriveled caps revive.

Owing to the fact that it grows in cold weather when other fleshy fungi are scarce there is little danger of confusing the velvet-stemmed Collybia with poisonous species. For the same reason it is not often seriously infested with worms. However, it is sometimes attacked by a white mold and the caps are frequently mutilated by slugs.

Preparation for cooking consists in the removal of the stems, picking off adhering leaves and blades of grass, and washing. Peeling of the caps is unnecessary.

A good way to cook the caps is to boil them for thirty minutes, then fry for fifteen minutes in butter, oleomargarin or bacon fat and season with salt and pepper. They may be served separately or on toast.

Any surplus which it is desired to preserve for future use may be dried. For this purpose, reasonably clean caps should be selected. The stems and adhering rubbish should be removed, but the caps not washed. Washed caps do not dry well. The washing should be postponed until just before the caps are to be cooked.

* Reprint of Bulletin No. 448, February, 1918.

THE VELVET-STEMMED COLLYBIA
(From an autochrome plate prepared by W. R. Fisher of the Department of Plant Pathology, New York State College of Agriculture)

1

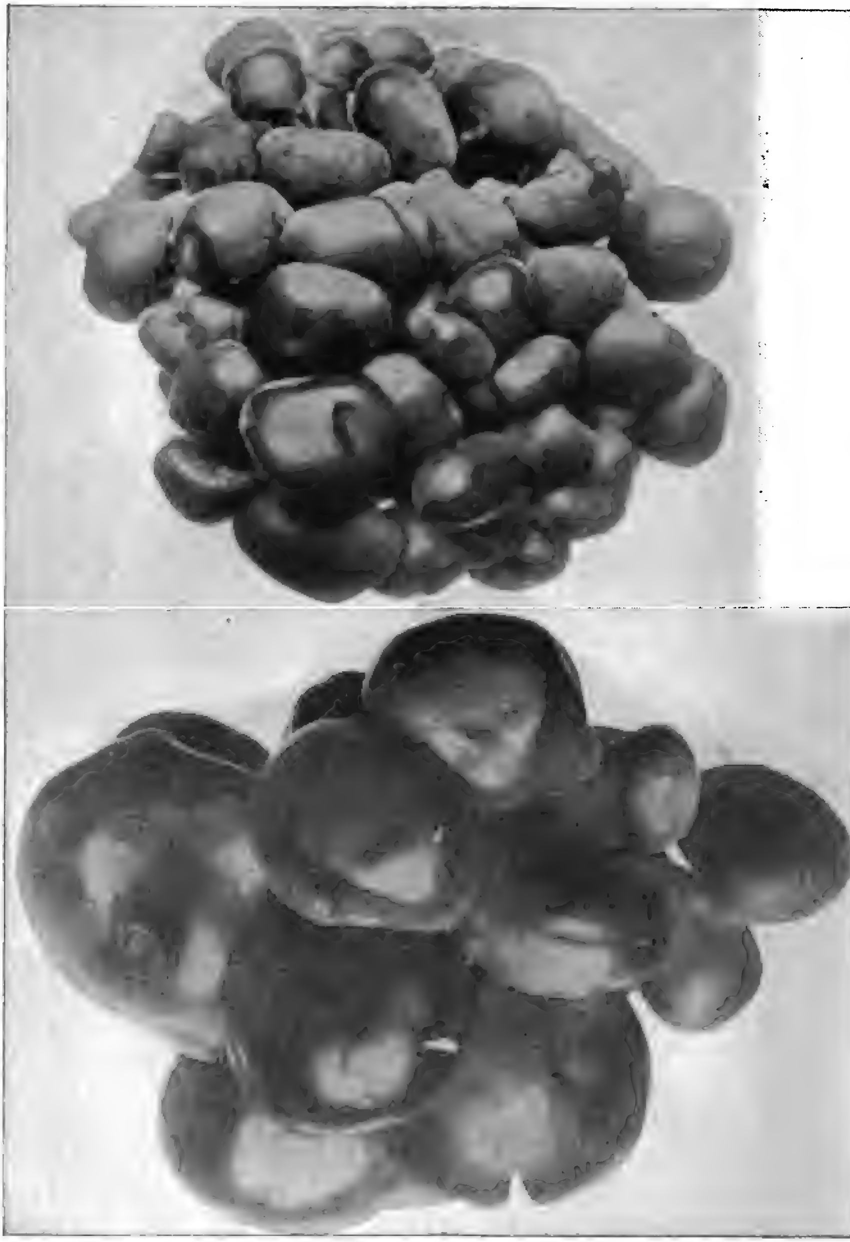
2

Plate I.—Clusters of ***Collybia velutipes.***

1

2

Plate I.—Clusters of *Collybia velutipes*.



1

2

Plate II.— Clusters of *Collybia velutipes.*

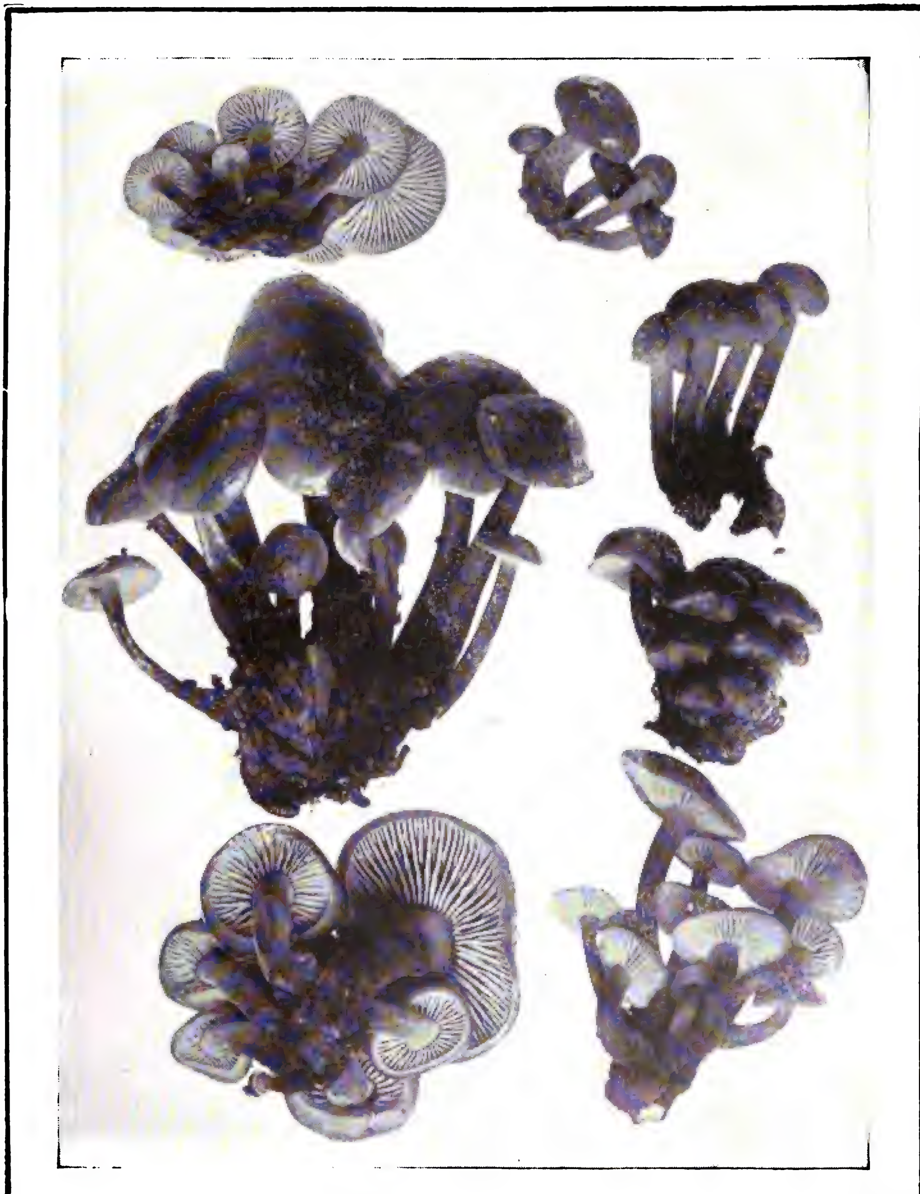


PLATE III.— CLUSTERS OF SMALL PLANTS OF *Collybia velutipes.*

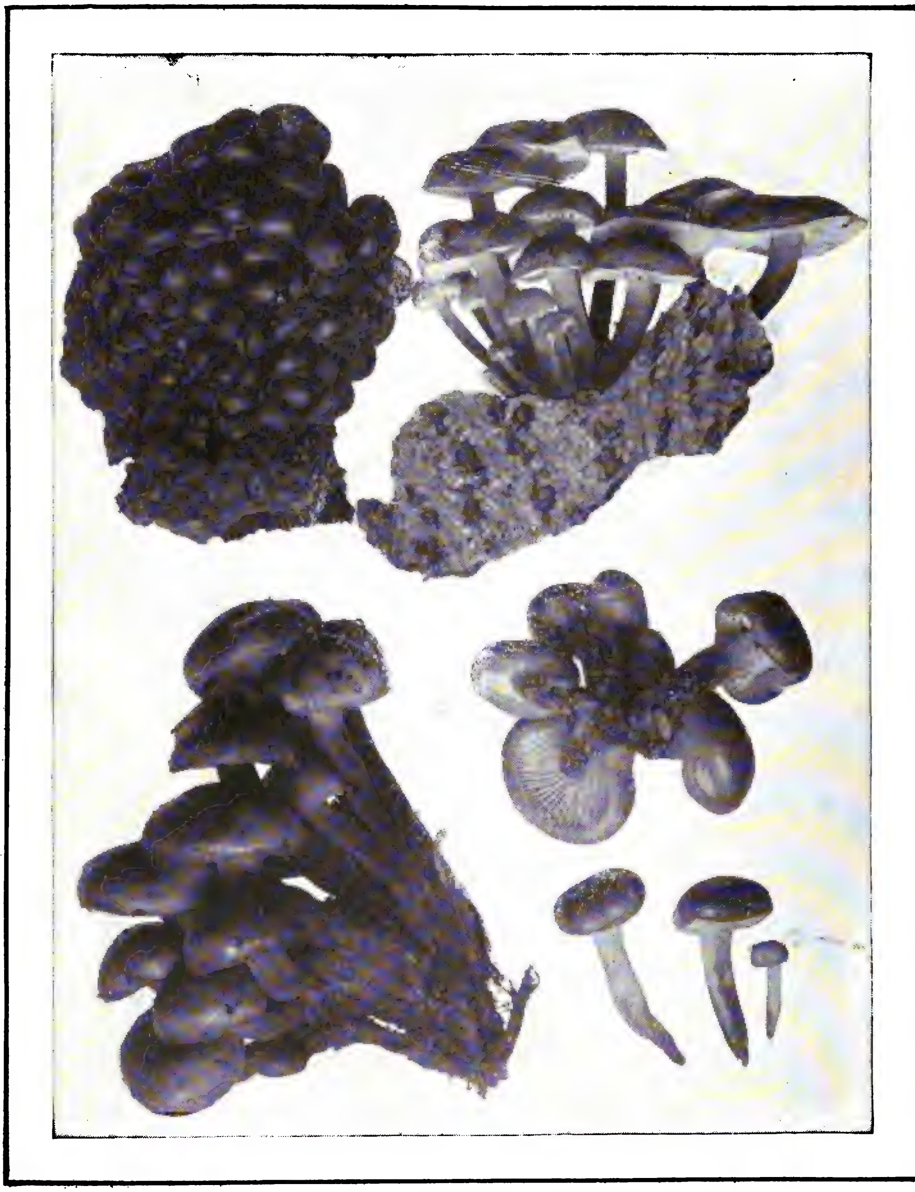


Plate IV.—Clusters of Young Plants of *Collybia velutipes*.

PLATE V.—MEDIUM AND LARGE SIZED CAPS OF *Collybia velutipes*.

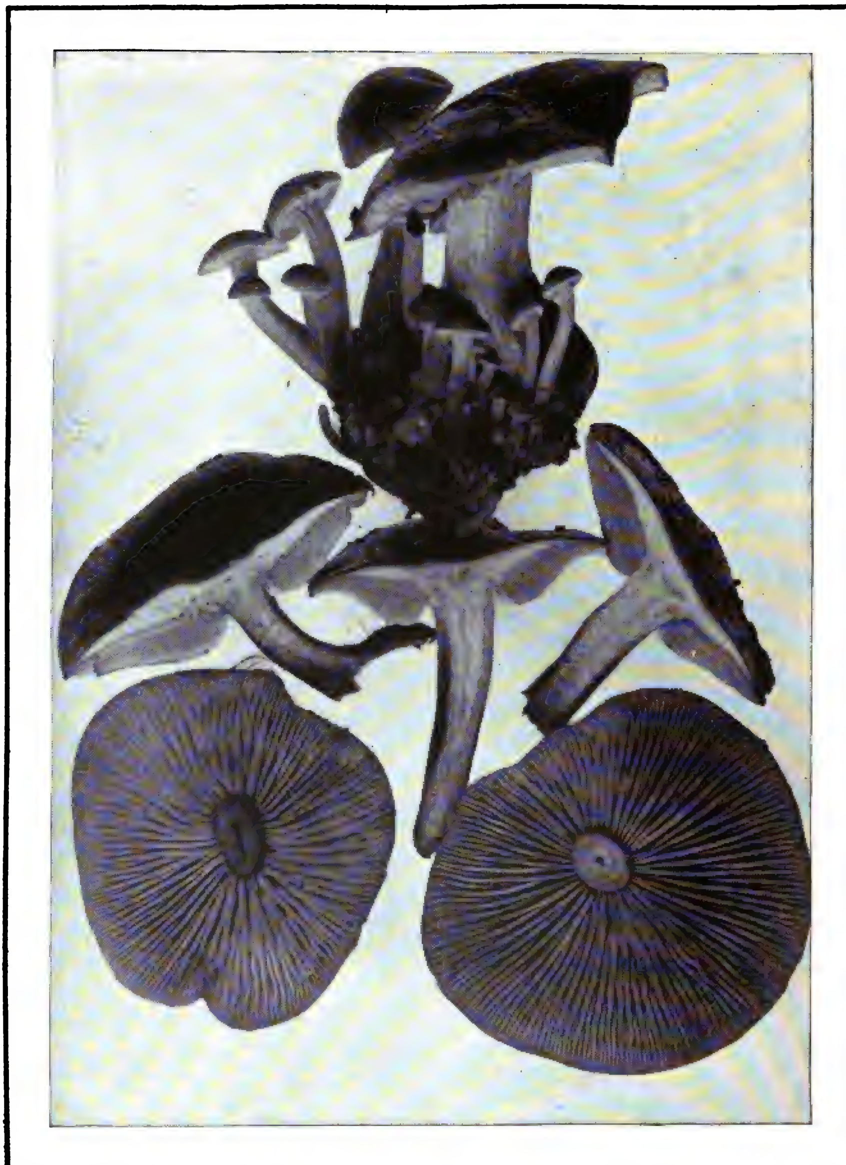


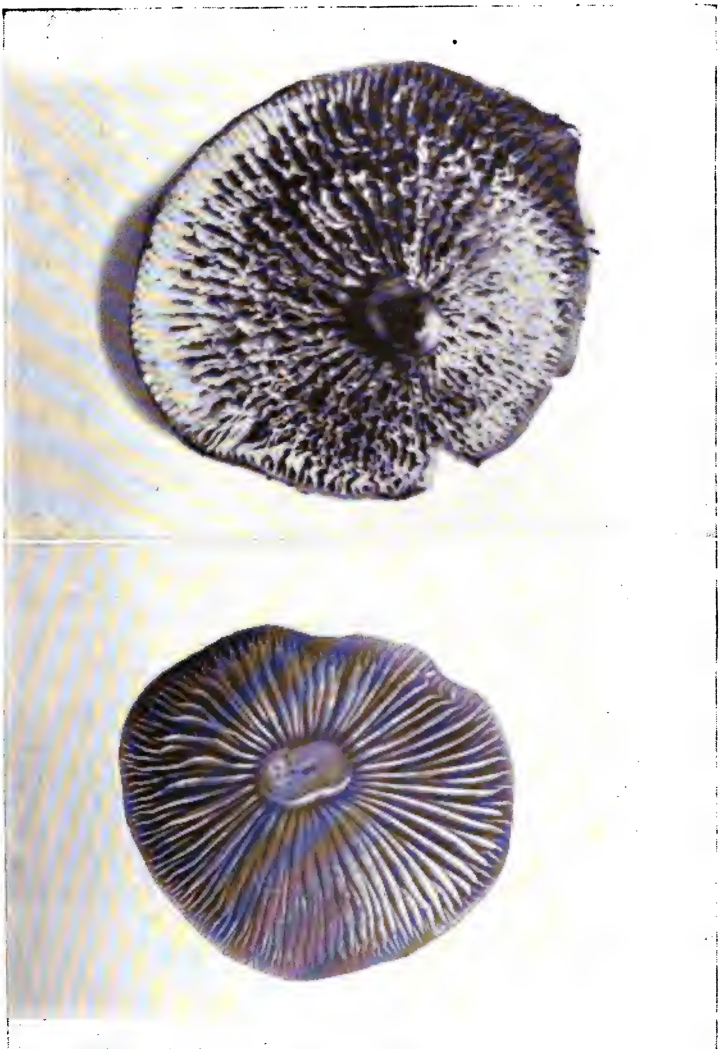
Plate VI.— Form and Structure of *Collybia velutipes*.

Plate VII.—Structural Details of *Collybia velutipes*.

1

2

PLATE VIII.—GROWING AND COLLECTED PLANTS OF *Collybia velutipes*.



1

2

Plate IX.— *Collybia velutipes* with Abnormal and Normal Gills.

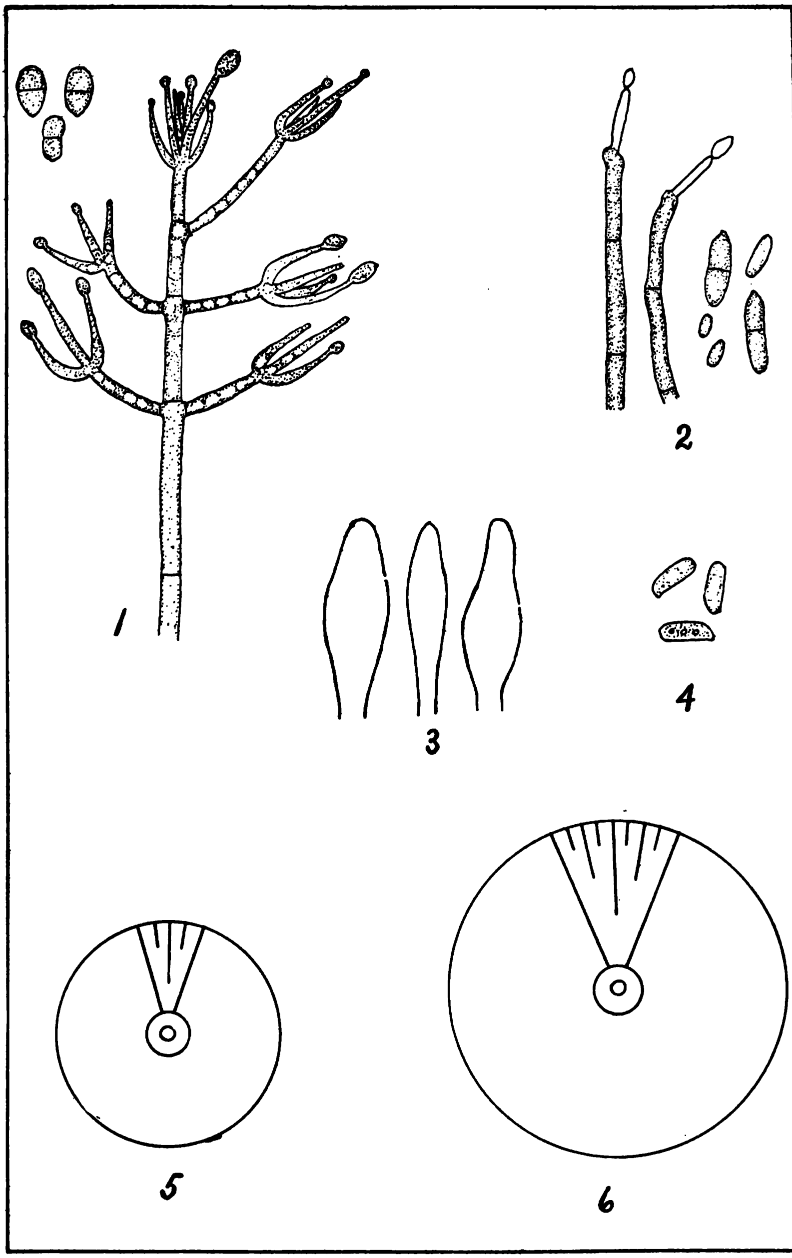


Plate X.—Fruiting Organs of Fungi and Gill Arrangement of ***Collybia velutipes.***

FLESHY FUNGI.

The fields, pastures and woods of New York abound in fleshy fungi of many kinds. They are called mushrooms, toadstools and puffballs. It is well known that a considerable number of these are edible and that some of them are of excellent quality. It is known, also, that some kinds are deadly poisonous. Owing to the difficulty of distinguishing the edible kinds from the poisonous ones comparatively few persons use wild mushrooms for food to any great extent. Vast quantities of good food of this kind go to waste every year.

This is regrettable, but appears to be very difficult to avoid. Even if they possessed the inclination the majority of people do not have the time necessary to acquaint themselves with the numerous kinds of mushrooms and toadstools. Unfortunately. none of the popular tests of edibility such as peeling, blackening of silver, etc., are dependable. There is no simple test which is of general application. He who would eat fleshy fungi in safety must know well the characteristics of each and every species he eats and let strictly alone everything which he does not know to be edible.

However, the necessary knowledge is neither extensive nor difficult to acquire. Any person of ordinary intelligence who is willing to put forth a moderate amount of effort may reasonably hope to become sufficiently acquainted with a considerable number of kinds of common, edible fungi to be able to recognize them almost as certainly as he does the common, cultivated plants.[1] Most cases of fatal toadstool poisoning result either from gross ignorance or the reckless disregard of common-sense precautions.

Acquaintanceship with the fleshy fungi should be cultivated. Every person should know at least a few of them. Altho their food value is not high they are not to be despised, particularly at the present time when food of all kinds is scarce and dear. They furnish a cheap, palatable addition to the menu. Besides, mushroom hunting is a pleasant and healthful form of recreation.

It is the purpose of this bulletin to give information concerning one of the common, wild mushrooms, the velvet-stemmed Collybia, the merits of which should be more generally known.

[1] The Station Botanist will cheerfully lend assistance by identifying such specimens as may be sent to him for that purpose. Specimens sent by mail should be fresh when started and packed in a stout box to prevent crushing. They should be addressed to the Experiment Station, Geneva, N. Y.

GENERAL APPEARANCE, HABITAT, RANGE AND SEASON.

The velvet-stemmed Collybia, *Collybia velutipes* (Curt.) Fr., is an agaric with a convex, reddish yellow cap, usually about an inch in diameter, and a brown, velvety stem commonly two or three inches long by one-fourth inch in diameter. The gills are white or yellowish. When wet the cap is very sticky.

It grows in dense clusters on the wood of various kinds of deciduous trees — on or about stumps, on the trunks of dead or dying trees, and on decaying logs and buried wood.

It is widely distributed thruout humid regions of the temperate zone. In New York, it is most abundant during October and November, but may be found in quantity also during periods of mild weather in winter and during May.

DETAILED DESCRIPTION OF COLLYBIA VELUTIPES.

In an article of this kind it is of the greatest importance that there be given a full and accurate description by means of which the fungus under consideration may be identified with certainty. As the basis of our account we may well use the following excellent description by Peck[2]: "Pileus rather thin, convex or nearly plane, obtuse, glabrous, viscid, reddish yellow or tawny; lamellæ broad, subdistant, rounded behind, slightly adnexed, white or tinged with yellow; stem firm, externally cartilaginous, stuffed or hollow, brown or tawny brown, velvety hairy when mature; spores narrowly elliptic, .0003 to .00036 of an inch long, .00016 broad.

"* * * It is easily recognized by its viscid, tawny cap, its velvety stem and tufted mode of growth. Sometimes the cap is wholly yellowish or yellowish on the margin and darker on the central part. Because of the crowded mode of growth the caps are sometimes very irregular. The gills are rounded or deeply notched next the stem, so that they are slightly attached to it. They are whitish or white tinged with yellow. In very young plants the stem is whitish, but it soon becomes tawny or tawny brown from the development of the dense coat of velvety hairs. It is usually hollow. The caps are generally about 1 inch broad in large tufts, but in smaller or looser clusters or in scattered or single growths they

[2] Peck, C. H. Report of the State Botanist on edible fungi of New York 1895–1899. Memoir of the N. Y. State Mus. Vol. 3, No. 4, pp. 144–145. 1900.

are often larger. The stems vary from 1 to 3 or 4 inches long and are from 1 to 3 lines thick."

Most of the characters given in the above description are illustrated in the plates in this bulletin. These plates should be carefully examined and compared with the description.

The shape of the pileus (cap) is so plainly shown in the plates that comment is unnecessary except to point out that in young specimens the margin of the pileus is strongly inrolled. This is seen in the figure in the lower left-hand corner of Plate III and in the middle figure on the right-hand side of Plate IV. The variation in size is well shown in the plates. All figures excepting those in Plate I, fig. 1, Plate VIII and Plate X are natural size. Only occasionally are plants found with the pileus over three inches in diameter. As stated in the description, the color of the pileus is somewhat variable. Its usual color is shown fairly well in the colored plate. Several colored illustrations of *Collybia velutipes* have been published, but none of them are really good. It is believed that the colored illustration in this bulletin is as accurate as any.

The surface of the pileus is smooth. To the unaided eye it appears wholly destitute of hairs, scales, wrinkles and striations. However, a microscopic examination often reveals the presence of a few short, yellowish brown hairs.

A prominent character is the viscidity of the pileus when wet. Leaves, blades of grass and particles of dirt coming in contact with the wet surface adhere to it so tenaciously that, when dry, it is often quite difficult to remove them except by washing. The flesh of the pileus is white and its taste agreeable — never bitter or acrid.

Plates II and IV show how the plants frequently grow in dense clusters.

The shape and width of the lamellae (gills) are best shown in Plates VI and VII. It should be observed that the gills, tho strongly rounded next the stem, are not entirely free from it. The spacing of the gills, also, is shown in Plates VI and VII. They are described as "subdistant," that is, they are neither very close together nor very far apart.

Invariably, the gills are unequal in length. Many of them do not reach the stem. In some plants there are three times as many short gills as long ones and the short gills are of two lengths; in others, there are seven times as many short gills as long ones and

the short gills are of three lengths. (Plate X, figs. 5 and 6.) The number of long gills (those extending from margin to stem) commonly varies from 25 to 50, being larger in large caps than in small ones. The short gills are often flexuous. Forked gills occur occasionally.

The edges of the gills, which under the microscope appear truncate in cross section, are beset with numerous hyalin, lanceolate cystidia. Similar cystidia occur, sparingly, also along the sides of the gills. (Plate X, fig. 3.) The spores are white, narrowly elliptic, 4×7.5–9μ.

"White or white tinged with yellow" describes well the color of the gills. At first, the gills are white, but they gradually become slightly yellowish with age. In very old specimens they may be decidedly yellow. The specimens shown in the colored plate are thoroly mature and the gills somewhat more yellow than usual.

A good idea of the usual appearance of the stem may be obtained from Plate I, fig. 2, and the colored plate. In mature plants the stem is covered with short brown hairs which give it a velvety appearance. This is most pronounced on the lower portion of the stem. The upper part of the stem is often very light in color and the stems of young plants may be white or yellowish white thruout.

TERATOLOGICAL FORMS.

IRREGULAR DOUBLE GILLS.

On December 10, 1911, the writer found three malformed plants of *Collybia velutipes* among a large number of normal ones growing in a cluster at the base of a dead willow tree. A week later, in the same place, ten additional plants were found showing the same malformation to a greater or less extent.

The malformation was one affecting the gills. Instead of being straight and even on the edge like a knife-blade, as is the case with normal gills, they were irregular and double-edged, with numerous lateral projections and a strong tendency to anastomose. (Plate IX, fig. 1.)

Apparently, this condition is rare. Altho, occasionally, specimens have been found showing traces of irregular, double-edged gills no other well-marked case has come to the writer's attention among the large mass of material examined during the past six years.

EXPLANATION OF PLATES.*

PLATE I.— Fig. 1.— A cluster of *Collybia velutipes* on an exposed root which shows at the right. The white objects in front and at the left are patches of snow. Altho the photograph was taken on January 16, after a period of zero weather, the mushrooms were in prime condition. About one-seventh natural size.

Fig. 2.— A typical cluster of *Collybia velutipes* showing the velvety appearance of the stems. Natural size.

PLATE II.— Fig. 1.— A dense cluster of small plants from the base of a stump. Natural size.

Fig. 2.— Surface view of a typical cluster of plants of average size. Natural size.

PLATE III.— Clusters of small plants. The cluster in the lower left-hand corner shows how the margins of young caps are inrolled. Collected and photographed January 13, 1916. Natural size.

PLATE IV.— Clusters of young plants. In the upper left-hand corner a dense cluster on a piece of bark; in the upper right-hand corner a loose cluster on a piece of bark; in the lower left-hand corner a typical fan-shaped cluster from beneath loose bark on a stump; in the middle on the right-hand side a cluster showing the inrolling of the margins of young caps. All natural size.

PLATE V.— Caps of medium and large size. Occasionally, caps larger than the one at the bottom of the plate are found, but they are not common. Natural size.

PLATE VI.— Form and structure of *Collybia velutipes*. The cluster at the top contains some very young plants. In the middle of the plate are three plants split lengthwise to show the shape of the gills and their mode of attachment to the stem. The two caps at the bottom show the arrangement and spacing of the gills and the hollowness of the stem. Photographed December 27, 1916. Natural size.

PLATE VII.— Group of plants showing the shape, arrangement and mode of attachment of the gills and structure of the stem. Natural size.

PLATE VIII.— Fig. 1.— Clusters of plants growing at the base of small stumps in typical fashion. About one-seventh natural size.

Fig. 2.— A basket of *Collybia velutipes* collected January 11, 1916. At the right of the basket is a stump with a cluster of *C. velutipes* at its base. About one-seventh natural size.

PLATE IX.— Fig. 1.— Cap of *Collybia velutipes* with irregular, double-edged gills.
Fig. 2.— Cap of *C. velutipes* with normal gills. Both figures natural size.

PLATE X.— Fig. 1.— Conidiophores and conidia of *Diplocladium minus* Bonord.
Fig. 2.— Conidiophores and conidia of *Cladosporium fuligineum* Bonord.
Fig. 3.— Cystidia from the edge of a gill of *Collybia velutipes*.
Fig. 4.— Spores of *Collybia velutipes*.
Fig. 5.— Diagram showing the 3-to-1 arrangement of short and long gills in *Collybia velutipes*.
Fig. 6.— Diagram showing the 7-to-1 arrangement of short and long gills in *Collybia velutipes*.

* Plates I–VIII, inclusive, are from photographs by F. S. Emmett and Plate IX from a photograph by G. T. French. Plate X is from drawings by the author.

SPOROPHORES FROM GILLS.

On a prostrate elm trunk at Ithaca, N. Y., the writer once found a robust young sporophore of *Collybia velutipes* with four small sporophores forming on its gills. The pilei of the secondary sporophores were perfect in form, but almost sessile. Three of them were 2 mm. in diameter while the fourth was smaller. With the aid of a hand lens the gills were readily distinguishable. No evidence of mutilation of the gills of the primary sporophore was detected. Brefeld has described and illustrated a similar phenomenon in *Coprinus stercorarius* which he produced by wounding the plants when very young.[3]

HABITAT.

Collybia velutipes grows on the wood of many kinds of deciduous trees, but not on conifers. Elm and willow are favorite hosts. Wherever stumps of these trees are plentiful good collecting may be expected. The favorite place of growth is on stumps at or near the soil line; but clusters are often found emerging from cracks in the bark at considerable distance above the ground. On the standing trunks of dead or dying trees, particularly elms in damp situations, the fungus may be found at a height of several feet. Prostrate trunks of elm and willow often yield large quantities. Also, partially buried wood and the partially exposed surface roots of stumps and dead trees are common places of growth for *C. velutipes*.

Our observations indicate that *C. velutipes* prefers wood in a comparatively early stage of decay. It is of little use to look for it on stumps or logs in an advanced stage of decay. The fungus is to be sought in new stump lots rather than in old ones. A stump may bear several crops each year for several years in succession and then cease to bear altogether.

In a pasture near Geneva, stumps of trees four to ten inches in diameter, cut in the winter of 1910–1911, began to bear a little in the autumn of 1912 and have borne good crops each year since. The trees were elm, beech, basswood and sugar maple. Older stumps of the same kind in an adjacent portion of the same pasture bore fairly well in 1911 and 1912 and produced a small crop in 1913, but

[3] Brefeld, O. Untersuchungen aus dem Gesammtgebiete der Mykologie. III. Botanische Untersuchungen uber Schimmelpilze. Basidiomyceten I, pp. 72–75. Leipzig. 1877.

none at all since. Apparently, the older stumps have passed their bearing age. Nothing is known of their history prior to 1911.

PARASITISM.

The preference shown by *C. velutipes* for the wood of newly-killed trees is in harmony with its semi-parasitic habit. The fungus is frequently found on the trunks of living trees, particularly those of elm and willow, and has often been suspected of being parasitic under certain conditions.[4] Münch and others have reported successful infection experiments with it.[5]

SEASON.

The velvet-stemmed Collybia is a cool-weather mushroom. It is useless to look for it in summer. Between June 15 and September 15, in this latitude, only occasional specimens are found — very rarely is the quantity sufficient for cooking. October and November are the best months for it. At Geneva, the first week in November may be considered the height of the season. It may be found in quantity, also, during spells of open weather in December, January and February. During March and April it is scarce; but considerable quantities may be collected again in May if the weather is wet and cool.

Because of its ability to endure low temperatures *Collybia velutipes* has sometimes been called "the winter mushroom." In this respect it is unique. With us, it is the only wild mushroom obtainable in quantity during winter. It may be frozen solid for days without affecting its quality or its ability to resume growth upon the return of mild weather. In fact, it may freeze and thaw several times without material injury to its esculent properties. During the past six years the writer has made fourteen winter collections, varying in amount from twenty to ninety ounces of cleaned caps, on the following dates: December 7 and 10, 1911; December 7, 1912; January 26, February 22 and December 24, 1913; February 7, 1914; February 22 and December 25, 1915; January 11, 13 and 31, 1916; and January 7 and February 28, 1917. One of these winter collections is shown in Plate VIII, fig. 2.

[4] Hennings, P. Die an Baumstämmen und Holz auftretenden teilweise parasitären heimischen Blätterschwämme. *Ztschr. Pflanzenkr.* 13:204. 1903.

[5] Münch, E. Versuche über Baumkrankheiten. *Naturw. Ztschr. Forst- u. Landw.* 8:389–408, 425–447. 1910.

Apparently, the plant is capable of growth at temperatures but slightly above freezing. Probably, it grows at any time when the ground is not frozen; but there is no reason to believe that it makes any growth while frozen. The observations recorded in the next three paragraphs bear on these points.

In December, 1914, at Geneva, there was a heavy fall of snow on unfrozen ground. The snow remained thru January and the first half of February. Then there came a spell of warm weather during which the snow melted rapidly leaving the ground bare except in places here and there where there had been deep drifts. On February 22, immediately after the disappearance of the snow, the writer gathered ninety ounces of caps of *Collybia velutipes* on an area of about two-thirds of an acre which had been thoroly searched and every cap of edible size removed only a few days before the snowfall in December. The Collybia plants must have grown under the snow during the winter. Some were considerably browned, others perfectly fresh; but nearly all were still in edible condition. Some, in prime condition, were taken from under the edges of melting snowbanks.

In 1917 a cluster of *Collybia velutipes* on a small willow stump was kept under observation from January 7 to March 22. During the greater part of this time the plants were covered with a few inches of snow; but they were also exposed at intervals. Except for a few brief periods the plants were frozen continuously from January 9 to February 26. Part of this time the weather was extremely cold. On six days the minimum temperature was below zero. One day, zero temperature was accompanied by high wind.

At the beginning of the observations the largest caps were one-half inch in diameter. They were but slightly larger on February 26, fifty days later. Then the weather became a little warmer and it rained. The caps started to grow. By March 11 they had attained a diameter of a trifle over an inch and appeared to be in prime condition; but from this time on they deteriorated. Tho still in edible condition on March 22 they were brown and dry on the margin and it was evident that they would not revive again.

MOISTURE RELATIONS.

The yield of *C. velutipes* is largely dependent upon moisture conditions. During periods of dry weather one may expect to find it only in damp situations and in small quantity. Collections made

in dry weather are usually very disappointing. On the other hand, in excessively wet autumns it grows abundantly on stumps, logs and dead wood in all sorts of situations. Ideal conditions for it are furnished when a heavy shower is followed by a few days of drizzling rain with the temperature around 40–60° F. After about a week of such weather (which is most likely to occur in October or November) good collecting may be expected.

Compared with some of the common warm-weather mushrooms *Collybia velutipes* is of slow growth. It does not appear suddenly after showers like the meadow mushroom, *Agaricus campestris*, but requires several days to reach maturity.

Caps of *C. velutipes* which have become shriveled during dry weather absorb water and partially revive when moistened. In this respect they resemble, considerably, the caps of the fairy ring mushroom, *Marasmius oreades*. Further discussion of this subject will be found on page 95.

QUALITY AND ECONOMIC ASPECTS.

As an esculent, *Collybia velutipes* has much to recommend it; but it possesses, also, a few objectionable features. In the first place, it may be said to be a fairly safe fungus. It bears little resemblance to any of the common poisonous species. Besides, it comes at a season when poisonous species are scarce.

Its flavor is excellent. Most mushroom eaters of the writer's acquaintance pronounce it first class. A few dislike the slippery condition due to the viscidity of the caps. However, this fault may be largely overcome by thoro cooking.

Its consistency, also, is entirely satisfactory. The caps are firm, but never tough no matter how old they may be. When properly cooked they are palatable and easily digestible. The stems, being tough, are never used.

The wide distribution and abundance of the fungus make it obtainable in quantity by large numbers of people. The plants are not large; but they grow in clusters which are often of considerable size and successive crops of them may be found in the same place year after year during their season.

Since they appear principally in cool weather they are not often seriously infested by worms or insects. Trouble with worms is confined chiefly to collections made during the forepart of October

and the latter part of May when the temperature is relatively high. At other times worms are scarce or entirely lacking. However, owing to the long duration of the caps under favorable conditions, wormy ones are occasionally found even in midwinter. On January 7, 1917, the writer found a few caps which, tho fairly fresh in appearance, contained live worms.

Another desirable quality due to the season of the fungus is the long time which it may be kept. Most mushrooms must be cooked within 24 hours after being gathered because they decay so quickly; but *Collybia velutipes* may be kept a week during the cool fall weather and still longer during the freezing weather of winter.

The most objectionable feature of the fungus is its viscidity. This makes it disagreeable to handle when wet and causes the adherence of leaves, grass and dirt which must be removed before cooking. The small size of the caps makes the cleaning process a slow one.

No attempt at the cultivation of *Collybia velutipes* is known to the writer. On account of its small size and the fact that it requires large quantities of decaying wood it appears improbable that it would be practicable to grow it in mushroom houses as the common *Agaricus campestris* is grown. But it might, perhaps, be grown out-of-doors on stumps. Since the fungus has its origin in spores it seems reasonable to expect that it might be encouraged to grow on stumps by placing about them the spore-laden caps and refuse which are unfit for cooking. It is worth trying. Stumps of elm and willow are the best subjects for experiments along this line. The writer has begun such experiments, but it is yet too early to expect results from them.

Taking all things into consideration, *Collybia velutipes* ranks high as an edible fungus of economic importance. It should be better known and more generally utilized.

METHODS OF GATHERING.

Under this head little need be said except to indicate the tools needed. During his rambles, the enthusiastic mycophagist always carries in his pocket one or two paper bags to hold any edible fungi which he may chance to meet. But when he goes on a real mushroom hunt he takes a basket and a large knife. All things con-

sidered, a covered ten-quart basket like the one shown in Plate VIII, fig. 2, is, perhaps, the most satisfactory. However, an uncovered basket is more convenient and one of larger size is often needed.

For the rapid and easy collection of *Collybia velutipes* one needs a knife with a long, sharp, flexible blade which may be run beneath the clusters to separate them from the stump or log upon which they are growing. If such a knife is not available a large pocket-knife will answer the purpose very well. Also, a pair of scissors may be used. Some tool with which to sever the stems is almost a necessity since they are very tough and attempts at breaking them result in severe mutilation of the caps.

Wormy, moldy and decaying specimens should be rejected. However, while collecting in the late fall and winter one often finds specimens which, tho much browned from repeated freezing and thawing, are, nevertheless, perfectly good. Also, in dry weather the caps may be much shriveled without loss of edibility. When washed, they absorb water and recover their freshness and turgidity.

CONFUSION WITH OTHER SPECIES.

REJECTION OF UNKNOWN SPECIMENS.

In gathering mushrooms of any kind for table use one should make it an invariable rule to *reject all unknown and doubtful specimens* no matter how inviting they may appear. This is best done in the field. Mutilated specimens are difficult to identify and when an attempt is made to sort mixed collections there is always danger that some of the "unknowns" may be overlooked and find their way into the frying pan. Mixtures gathered by children and uninformed persons are dangerous unless thoroly inspected by an expert.

During a large part of the season for *Collybia velutipes* other kinds of fleshy fungi are very scarce. This fact greatly facilitates its identification and, to a large extent, obviates the danger of confusing it with poisonous species.

SPECIES OF AMANITA.

The deadly poisonous species of Amanita, besides being very different from *C. velutipes* in color, grow singly instead of in clusters; also, the stem is surrounded at the base by a sort of cup called the

volva, and, higher up, it bears a ring, or annulus. *C. velutipes* has no trace of either a volva or an annulus. Only a very careless or a very stupid person would mistake an Amanita for *Collybia velutipes.* The writer has never observed any species of Amanita actually growing in company with *Collybia velutipes.* However, such association is entirely possible. *Amanita mappa* Fr., a species with a straw-colored or pale yellow cap, occurs frequently in the woods of central New York all thru October; and the writer has found occasional specimens of *Amanita porphyria* Fr. at Ithaca as late as October 31.

CLITOCYBE ILLUDENS.

Clitocybe illudens (Schw.) Fr. is a showy, yellow fungus which grows in clusters about stumps. Its season being from July to October it is occasionally encountered early in October by persons seeking *Collybia velutipes.* However, it is quite a different fungus. It is considerably larger than *C. velutipes,* the caps being three to six inches in diameter and the stems three to six inches long. Also, it is of rich saffron-yellow color thruout and the gills are decurrent, that is, they extend downward on the stem. While this fungus is not poisonous it should be avoided because some persons are made sick by eating it.

ARMILLARIA MELLEA.

Armillaria mellea (Vahl.) Quel. is one of the few fleshy fungi which the collector of *Collybia velutipes* is sure to meet. It grows in much the same sort of places as *C. velutipes* and is very common during October. As this is an edible species (tho of second quality) fungus-eaters should make its acquaintance. However, the scope of this bulletin does not permit of a detailed description of it. For our purpose it is sufficient to indicate how it may be distinguished from *C. velutipes.* The cap of *C. velutipes* is smooth and very viscid when wet, while the cap of *A. mellea* is more or less covered with scales consisting of tufts of short hairs and is never viscid. The stem of *C. velutipes* is always without an annulus; that of *A. mellea* occasionally lacks an annulus, but usually bears one of cottony texture. *A. mellea* is an extremely variable species. Usually, it is yellowish brown and considerably larger than *C. velutipes.* It is unlikely that anybody who has once recognized *C. velutipes* would mistake *A. mellea* for it; but no harm would be done if the two species should be confused.

HYPHOLOMA SUBLATERITIUM AND H. PERPLEXUM.

The brick-top, *Hypholoma sublateritium* (Schaeff.) Fr., is another common edible fungus which is found during a portion of the season for *Collybia velutipes* and in similar situations. It grows in large clusters on the ground around stumps and over buried wood during October and November. The caps are fleshy, brick red at the center and paler around the margin. Usually, this is much larger and stouter than *C. velutipes*, the caps being two to five inches across and the stems one-half to three-fourths of an inch in diameter; but small specimens, when viewed from above, sometimes resemble *C. velutipes* so closely as to deceive even the experienced collector. In doubtful cases the color of the gills establishes the identity of the fungus at once. If the gills are white or yellowish white it is *C. velutipes*; if they are greenish yellow, sooty, olivaceous or purplish brown it is either *Hypholoma sublateritium* or a closely related species, *Hypholoma perplexum* Pk. Since both of these species are edible an error in identification would have no harmful result.

COPRINUS MICACEUS AND HYPHOLOMA APPENDICULATUM.

While collecting *Collybia velutipes* in May the writer has often taken large quantities of the inky cap (*Coprinus micaceus* (Bull.) Fr. and *Hypholoma appendiculatum* Bull. (= *H. incertum* Pk.) These two species are edible. Also, they are so different from *C. velutipes* that even a novice would not confuse them with it.

PREPARATION FOR COOKING.

The preparation for cooking consists of: (1) The removal of the stems; (2) the removal of leaves, grass and other rubbish adhering to the caps; (3) separating out wormy, decaying and moldy specimens; and (4) washing. In general, the first three of these operations should be performed the same day the mushrooms are gathered while the fourth is best done just before cooking.

The writer has found the following methods satisfactory: A newspaper is spread on a table and the mushrooms dumped onto it in a pile. Two dishes are provided — one for the good caps, the other for the refuse. A good light is desirable, particularly if some of the specimens are wormy. With a pair of scissors the stems are severed close up to the cap; or, the stems of the larger caps may be broken

out. When worms are present the latter is the better method since it is necessary to break open the caps to look for worms. The larger pieces of leaves and grass adhering to the caps are picked off with the fingers; but small pieces may be left to be removed in the washing. If the mushrooms are the least bit damp the viscid substance on the caps causes the fingers to become sticky and dirty making it necessary to wash the hands every few minutes.

Just before cooking, the caps are thrown into a large pan of water and vigorously stirred and rubbed between the hands for about a minute after which they are lifted out. The dirty water is then thrown away, a quantity of clean water placed in the pan and the washing process repeated. Usually, two washings are sufficient, but a third may be necessary if the specimens are very dirty or have not been carefully freed from grass. Occasional caps which are very dirty will require individual attention, but most of the washing is done *en masse* and need not take more than five minutes altogether. The small and medium-sized caps may be cooked whole, but the larger ones should be cut into pieces. Peeling of the caps, as recommended by Peck,[6] is not only unnecessary but impracticable.

COOKING.

There are several ways of cooking mushrooms. Doubtless, *Collybia velutipes* may be made into an appetizing dish by any one of several different methods known to skilful cooks. An authoritative discussion of these methods would form a valuable addition to this bulletin. Unfortunately, the writer's experience in the cooking of mushrooms is confined almost exclusively to a single method, namely, that of frying. Accordingly, he must content himself with giving an account of his method of frying *Collybia velutipes*.

After the caps have been washed as described on a previous page they are placed in a frying pan over the fire and salted. The caps are then boiled until the water which they contain has almost all evaporated. The boiling process should consume about thirty minutes. If the boiling proceeds slowly the water contained in the

[6] Peck (*Loc. cit.*, p. 145) says: "It is well to peel the caps before cooking in order to free them from adhering particles of dirt or other objectionable matter." It is incomprehensible that one so well acquainted with edible fungi as Dr. Peck should make a recommendation so impracticable. The "peel" is very thin and so tender that careful manipulation is required to remove it. It would be a large task to peel enough caps for a meal for a family. No cook could be induced to try it a second time.

caps is sufficient; but with rapid boiling it will be necessary to add a little water to prevent burning before the end of the half-hour period.

When the boiling is completed butter, oleomargarin or bacon fat is added and the caps are fried over a brisk fire for about fifteen minutes. Frequent stirring is required to prevent burning. While the frying is in progress pepper is added for seasoning.

In case of necessity the whole process of cooking may be brought within half an hour, but better results are likely to be had when more time is taken. If not boiled long enough the caps are somewhat tough. If not fried long enough they will be slippery. They may be served as a separate dish or on toast.

This simple method of cooking is highly satisfactory for *Collybia velutipes*. In fact, it is one of the best methods for cooking mushrooms of almost any kind; but, of course, it must be varied somewhat to suit the requirements of different species.

PRESERVATION BY CANNING AND DRYING.

Altho the writer has never attempted to can *Collybia velutipes* and knows of nobody who has done it, he is confident that the fungus may be canned successfully by the methods used in canning other kinds of mushrooms.

The writer's experience with the drying of *Collybia velutipes*, also, is limited, yet sufficient to convince him that this method of preserving the surplus is entirely practicable and probably more satisfactory than canning. Of course, the dried article is not quite as palatable as that freshly gathered; but the difference is not great.

Specimens selected for drying should be such as can be made reasonably clean without washing. The washing must be postponed until a short time before cooking. On account of the large quantity of water taken up in the process of washing, washed caps are difficult to dry. The writer once washed a quantity of caps and then attempted to dry them in a shallow pan on top of the warming oven of a kitchen range. Altho uncovered and spread in a thin layer the caps became partially cooked and dried down into a shapeless black mass having an offensive odor.

Subsequently, excellent success was had with unwashed caps dried more slowly. After the removal of the stems and adhering bits of rubbish the caps were put into an open dish which was placed near

the kitchen ceiling about five feet above and a little to one side of the cook-stove. At the end of a week the caps were transferred to a closed paper bag which was left in the same place five weeks longer. During this time the caps lost 89 per ct. of their weight and became thoroly dry. Doubtless they would have kept here in good condition all winter, but it being desired to test their edible properties they were prepared for cooking. After soaking in cold water for three hours they were softened and swollen sufficiently for washing, but did not regain their original turgidity by considerable. While cooking they appeared much like fresh specimens and their palatability was but slightly inferior to that of fresh specimens.

Once, during winter, the writer left a quantity of *C. velutipes* in an unheated room for over three weeks. The caps became dry and shriveled but did not decay in the least. After being soaked and washed they were cooked and found to be of good quality.

It seems probable that drying might very well be commenced in the sun and completed over a stove. An ounce of dried caps is equivalent to from ten to fifteen ounces of fresh ones.

CAPACITY OF THE CAPS FOR THE ABSORPTION OF WATER.

On previous pages brief mention has been made of the fact that shriveled caps of *Collybia velutipes* become turgid when moistened. They possess a remarkable capacity for the absorption of water. Under different conditions their water content varies so much that it is impossible to express it accurately in terms of percentage. This was brought out very clearly in some simple experiments made by the writer.

FIRST EXPERIMENT.

A quantity of caps [7] weighing 23 ounces when first collected in the latter part of October weighed only 2.5 ounces after six weeks of drying in a paper bag hung near a cook-stove. Thus their water content appears to have been approximately 89.1 per ct. These caps were rather dry, but only slightly shriveled when gathered.

[7] In all of these experiments only clean, edible caps were used. The stems had been removed by cutting them off close to the caps.

SECOND EXPERIMENT.

In January, a quantity of fresh caps in prime condition weighed 19.5 ounces when first gathered. After being weighed they were put into a pan of cold water and washed, then transferred to a colander to drain. During the process of draining they were removed from the colander three times and thoroly mixed in order to give opportunity for the escape of water caught between the gills. The draining was continued for several minutes after water ceased to drip from the bottom of the colander. The caps were then weighed a second time and their weight found to be 34 ounces. During the process of washing their weight had increased 74.3 per ct.

THIRD EXPERIMENT.

Another collection made on the same date as the above, but in a different locality, contained some specimens which were quite old and a few shriveled ones; but all were in edible condition. This lot weighed 13.5 ounces when first gathered and 28 ounces after being washed and drained as described in the second experiment. In this case there was an increase in weight of 111.1 per ct.

FOURTH EXPERIMENT.

A November collection containing many shriveled caps weighed 20.5 ounces when first gathered and 47 ounces after being washed and drained. In this case the increase in weight equalled 131.7 per ct. Caps which were much shriveled at the time of the first weighing appeared plump and fresh at the second one.

FIFTH EXPERIMENT.

Forty ounces of caps collected February 28, 1917, were divided into two equal lots which were washed and drained separately as described above. When weighed a second time the two lots had exactly the same weight, namely, 27.75 ounces. Hence, washing increased their weight 35.7 per ct. Many caps of both lots were frozen and some were much browned at the time of the first weighing, but all were in edible condition.

DISCUSSION OF THE RESULTS.

In the above experiments the increase in weight which resulted from washing is due entirely to water taken up; but it is unknown

how much of the water was actually absorbed into the tissues and how much adhered to the surface. The gills present a large area of surface to hold water by adhesion. However, the fact that shriveled caps became turgid is proof positive that some water was absorbed. Also, it appears that the wide variation in the amount of water taken up in the four experiments was due chiefly to differences in the absorptive power of the caps, because there seems to be no good reason for believing that different lots of caps should vary much in their capacity for holding water by adhesion.

WHITE MOLD.

When gathering *Collybia velutipes* for table use one often finds specimens infested with a cottony white mold which covers large areas on the gills and stem. Altho such specimens may not be old ones they should be rejected because the moldy parts are brown and decayed. Sometimes large clusters appearing sound externally are so overgrown with mold on the interior as to be almost entirely worthless. Moldy specimens are most plentiful during October and May when the weather is comparatively warm; but some are found even in winter. Once the writer found several on February 22 in such fresh condition as to make it appear probable that both the mold and its mushroom host were of recent growth.

In the great majority of cases microscopic examination of the mold when first collected fails to reveal the presence of spores other than those of the mushroom. However, the mold sporulates freely in a moist chamber. When a fresh cap with a spot of mold on its gills is put into a moist chamber and subjected to a temperature of about 70° F. the entire cap becomes overgrown with the mold in from two to four days. The growth of mold is loose, snow white, very luxuriant (one-fourth to one-half inch high) and covered with multitudes of spores which are hyalin, egg-shaped, two-celled and measure 15–20 x 7–9 μ. The spores are borne singly on the tips of club-shaped branches which have a verticillate arrangement. (Plate X, fig. 1.)

This white mold is a species of Diplocladium — either *D. majus* Bonord. or *D. minus* Bonord. Apparently, these two species are very similar. Both are said to occur on decaying agarics and polypores belonging to several different genera;[8] but the writer has observed the mold described above only on *Collybia velutipes* and it

[8] Lindau, G. Rab. Krypt. Fl., Zweite Aufl., 1[8]: 373. 1907.

seems to be parasitic. Peck mentions the occurrence of *Diplocladium minus* on "decaying agarics and polypori" in the Helderberg mountains of eastern New York.[9]

A second white mold is sometimes found on *Collybia velutipes*. In the field its appearance is similar to that of Diplocladium, but in moist chamber it is readily distinguished by its much slower and less luxuriant growth. It has never been observed to produce spores. Its identity has not been determined.

OLIVE GREEN MOLD.

Among a lot of caps collected May 6, 1917, there was one the upper surface of which was covered with dark-colored elevations. The appearance of these elevations under a hand lens suggested fungus stromata imbedded in the flesh of the mushroom; but upon examination of sections under a compound microscope they were found to consist of a compact layer of the unbranched conidiophores of some fungus. Some of the conidiophores bore immature conidia on their tips and a few free, one-celled and two-celled conidia were in evidence. After being 16 hours in a moist chamber the entire surface of the cap was olive green with multitudes of conidia which were mostly one-celled. Two days later, after the specimen had been allowed to dry, many two-celled conidia were found. The conidia were very variable in size, the larger ones measuring 15–20 x 7 μ. The conidiophores have a peculiarity which should be of assistance in the identification of the fungus. A short distance below the tip there is an abrupt enlargement. Above this enlargement the conidiophore is hyalin; below it, colored. (Plate X, fig. 2.) The fungus has been identified as *Cladosporium fuligineum* Bonord.[10] It appears to be parasitic.

SLUGS, MILLIPEDS AND ANIMALS.

A great many caps are mutilated by slugs which feed upon them freely. Frequently specimens are found with the gills almost entirely eaten away. During cold weather millipeds or thousand legged worms congregate in clusters of the caps and probably feed upon them to some extent. The writer has sought, but never found, evidence that the caps of *Collybia velutipes* are eaten by animals. Even sheep in close-grazed pastures do not molest them.

[9] Peck, C. H. Report of the Botanist. N. Y. State Mus. Rpt. 34: 48. 1883.
[10] Bonorden, H. F. Abhandlungen aus dem Gebiete der Mykologie I, p. 92. Halle, 1864.

REPORT

OF THE

Department of Chemistry

LUCIUS L. VAN SLYKE, *Chemist.*

*RUDOLPH J. ANDERSON, *Associate Chemist.*

ARTHUR W. CLARK, *Associate Chemist.*

JOHN C. BAKER, *Associate Chemist.*

MORGAN P. SWEENEY, *Assistant Chemist.*

OTTO MCCREARY, *Assistant Chemist.*

RICHARD F. KEELER, *Assistant Chemist.*

WILLIAM F. WALSH, *Assistant Chemist.*

WALTER L. KULP, *Assistant Chemist.*

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* In war service.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

STUDIES RELATING TO MILK.*

SUMMARY.

I. THE PREPARATION OF PURE CASEIN.

LUCIUS L. VAN SLYKE AND JOHN C. BAKER

1. Casein in pure form, free from inorganic phosphorus, calcium, and hydrolytic products, is prepared by treating undiluted milk with normal acid, preferably lactic or a mixture of one part of hydrochloric and one or two parts of acetic. The acid is introduced into the milk below the surface, the tip of the tube carrying the acid into the milk being so arranged that it is very close to a mechanical stirrer revolving at a high speed and also near the bottom of the vessel containing the milk. Under these conditions, the acid does not cause coagulation of the casein at the point where the acid first comes into contact with a portion of the milk.

2. The acid is run in slowly until about 60 cc. per liter of milk has been added, the stirrer making 2,000 to 3,000 revolutions per minute. The mixture is allowed to stand three hours with gentle stirring, when about 20 cc. more of acid is slowly added under rapid stirring, after which the mixture is stirred gently two to four hours.

3. The mixture is then centrifuged, the supernatant liquid being decanted, the casein beaten to a homogeneous mass with water, centrifuged, decanted and similarly washed with water four or five times. It is then similarly washed twice with 95 per ct. acid-free alcohol and then three times with acid-free ether, after which it is spread out on a smooth surface and allowed to dry, being kept stirred while drying.

4. Ash and phosphorus content is kept low, being about 0.10 per ct. of ash and 0.80 per ct. of phosphorus, with no calcium.

5. By this method casein can be prepared within ten hours. Excess of acid with danger of hydrolysis is avoided. Contact with reagents is reduced to a minimum. The product is a very fine white powder. It contains neither inorganic phosphorus nor calcium. It dissolves at once in dilute solutions of mono-basic alkalis and also in excess of lime-water to a clear solution. Lime-water solutions of this casein, when neutral, are opalescent. The yield of the casein from milk is practically quantitative.

* Reprint of Technical Bulletin No. 65, December, 1918.

II. A METHOD FOR MAKING ELECTROMETRIC TITRATIONS OF MILK AND OTHER SOLUTIONS CONTAINING PROTEINS.

JOHN C. BAKER AND LUCIUS L. VAN SLYKE

1. The method described enables one to make numerous electrometric titrations accurately in one solution in the presence of proteins.

2. The apparatus consists of a wide-mouth bottle, holding about 400 cc., in which the electrode is placed and in which the reaction occurs. The neck is provided with a cork stopper containing perforations thru which pass into the bottle the several parts or connections. The hydrogen electrode, made of platinum foil, is suspended in a special manner inside the bell-shaped end of the tube carrying hydrogen, and is so arranged that it can be lowered into, or drawn up out of, the solution titrated. Other parts are (a) a glass tube carrying the titration reagent from a burette into the solution titrated, (b) a special stirring-apparatus, (c) a tube for introducing additional reagents, (d) a tube containing KCl, and, in addition, other pieces of standard apparatus required to measure hydrogen ion concentration.

3. The apparatus has the advantage of enabling one to prevent (a) interference by dissolved oxygen, (b) local chemical action at point where the reagent enters the solution under titration, (c) foaming of solution, (d) deposition of protein on electrode, and (e) interference by bacterial action or hydrolysis.

4. In operating, the solution under examination is placed in the bottle, the volume and temperature are adjusted, and all bubbles are removed. The parts of the apparatus are assembled in position, the electrode being above the solution. Hydrogen is run in freely and air displaced. The stirrer is set in motion. The electrode is lowered into the solution, electric connections made, equilibrium established and then $n/_1$ titration reagent run in. Readings of E. M. F. are made once a minute until constant. Titrations are made until the desired number of values is obtained. The method permits rapid work.

III. FREE LACTIC ACID IN SOUR MILK.

LUCIUS L. VAN SLYKE AND JOHN C. BAKER

1. The work was undertaken to ascertain how much free lactic acid is present in sour milk. Lactic acid exists in sour milk largely as lactate but partly as free acid. Part of the free acid is in solution, while a smaller part is adsorbed by the casein. Each must be determined separately. In addition, a study was made of the acidity of sour milks, the coagulation point of casein in sour milk, and the first sign of souring.

2. In all experiments the milk was kept at 25° C. during the souring process. Freshly separated skim-milk, pasteurized at 62° C., cooled to 25° C., was inoculated with ***Bacterium lactis acidi***. In studying the acidity of sour milks, samples were inoculated with other organisms also.

3. In determining the amount of free lactic acid, three different methods were employed, with results in good agreement: (a) Measurement of hydrogen ion concentration and application of calculation based on the Mass-Law; (b) partial extraction by ether and application of calculation based on coefficient of distribution; (c) double electrometric titration with lactic acid and hydrochloric acid. Under the conditions of the experiments, free lactic acid does not appear in appreciable amounts in souring milk for about 20 hours after inoculation, when there is present 0.1 cc. of $n/_{10}$ acid in 100 cc. of milk; this increases more rapidly in the next few hours and finally in 48 hours it is about 20 cc. The pH value changes from 6.5 in fresh milk to 4.17 in 48 hours.

4. In estimating the amount of free lactic acid adsorbed by casein in sour milk, four methods were used, giving consistent results: (a) Measurement of reduction of hydrogen ion concentration caused by adding casein to lactic acid solutions of given concentrations; (b) measurement by titration of acidity caused by adding casein to lactic acid solutions; (c) titration of acidity of sour milk and of separated whey; (d) extraction of lactic acid in sour milk by ether and in separated whey. About 20 per ct. of the free lactic acid in coagulated sour milk is adsorbed by casein.

5. In making study of the acidity of milk soured under different conditions, fresh separated milk was soured at 25° C., after preliminary treatment in the following ways: (a) Pasteurized milk inoculated with (1) ***Bacterium lactis acidi***, (2) with ***Bacillus bulgaricus***, and (3) ***Streptococcus lacticus***; (b) unpasteurized milk (1) inoculated with a sour-milk " starter ", (2) self inoculated. The total acidity by titration varied from 70.5 to 220 cc. of $n/_{10}$ acid per 100 cc. of milk; the free lactic acid, from 8.6 to 104 cc.; the acid as lactate, from 51.8 to 92 cc.; the pH value from 3.70 to 4.56. In milks souring under ordinary conditions, the total acidity by titration varied from 70.5 to 107.5 cc. of $n/_{10}$ acid per 100 cc. of milk; the free lactic acid, from 13.1 to 34.5 cc.; the pH value from 4.02 to 4.43.

6. The casein of milk begins to coagulate when the pH value reaches 4.78 to 4.64. The time from the beginning of coagulation to completion varies from 30 to 60 minutes, during which period the hydrogen ion concentration remains constant, tho the acidity by titration increases slightly.

7. The first physically and easily perceptible sign of souring in souring milk is a characteristic flavor, discernible to the senses of both taste and smell, due to the presence of some volatile compound

formed in the souring process and not to lactic acid. The flavor appears before the milk begins to taste acid. There is no apparent relation between either the hydrogen ion concentration or acidity by titration and the first sign of this flavor.

I. THE PREPARATION OF PURE CASEIN.

LUCIUS L. VAN SLYKE AND JOHN C. BAKER.

The method which has long been in common use for the preparation of casein from cow's milk is the one originally devised by Hammarsten. This consists essentially in separating casein from diluted milk by means of acid, filtering and washing the separated casein, and dissolving it in dilute alkali, after which the processes of coagulation by acid, filtration, washing, and redissolving are repeated four or five times. While modifications in some minor details have been proposed, the preparations of casein obtained by the Hammarsten method and its modifications have been of questionable purity in one or more respects. Such preparations of casein usually contain calcium phosphate, calcium caseinate and probably also products of hydrolysis due to exposure of the casein to alkali, acid, and water for unusual periods of time.

In studying the work of Van Slyke and Bosworth [1] it was noticed that soon after milk coagulates in the ordinary process of souring, all of the calcium and inorganic phosphorus of the milk is in solution. This fact suggested the possibility of preparing a pure casein that would not be subjected to the objectionable conditions connected with the Hammarsten process. It occurred to us that if an acid could be introduced into undiluted milk in a manner resembling the formation of acid in the natural souring of milk, the objectionable features could be obviated and a pure product obtained. The most important condition of natural souring to be thus approximated is the gradual addition of acid and its immediate distribution thru the mass of milk without causing coagulation of casein at the point where the acid first comes into contact with a portion of the milk. This result can be accomplished by introducing the acid below the surface of the milk with simultaneous high-speed mechanical stirring, the tip of the tube that carries the acid into the milk being so arranged that it is very close to the stirrer and near the bottom of the vessel containing the milk (see Fig. 1). The details of the application of this principle have been developed in practical use and are here presented.

[1] Van Slyke, L. L., and Bosworth, A. W., N. Y. Agrl. Expt. Sta. Tech. Bul., 48, 1916, and *J. Biol. Chem.*, 24:191, 1916.

METHOD.

DESCRIPTION OF APPARATUS.

The apparatus used in coagulating casein in milk by adding acid under the surface with rapid stirring consists of four main parts: the vessel, the burette, the acid-carrying tube, and the stirrer (see Fig. 1).

(1) *Vessel holding milk.*— The container (A) in which the coagulation of casein takes place may consist of any suitable open vessel, such as a wide-mouthed bottle, a precipitating jar, or an ordinary granite-ironware pail, having a capacity of 1 to several liters according to individual requirements. It is desirable that the vessel should be of relatively low form, since it is more difficult to stir the entire body of the milk satisfactorily if it is in too deep a layer, and also there is a greater tendency to vibration of stirrer.

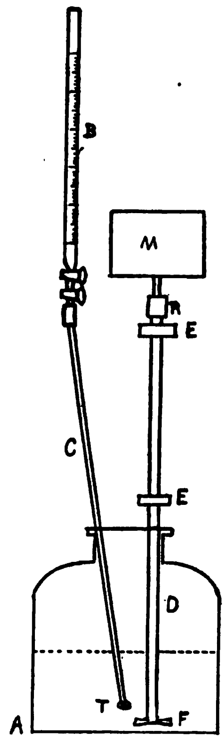

FIG. 1.

(2) *Burette.*—The burette (B) holding the acid is an ordinary one. While only one stop-cock is necessary, two are convenient, one to serve as a shut-off, and the other to regulate the flow of acid.

(3) *Tube carrying acid.*— The capillary glass tube (C), which carries the acid from the burette into the milk, needs detailed description. The diameter of the bore of the tube should be 1.5 to 2 mm. The special construction of the delivery tip (T) of this tube is important. It should be bent upward somewhat and the opening should be flattened and widened in the form of a narrow slit. The object of the slight upward bend is to prevent milk or particles of coagulated casein from being forced into the delivery tube and interfering with the flow of acid by clogging. The upper end of the delivery tube is connected with the burette tip by means of a close-fitting connection of rubber tubing. Care must be taken not to permit any strain at this rubber joint during the delivery of acid into the milk because such strain may draw milk or particles of casein into the tube, causing stoppage. For this reason a pinchcock cannot be used in place of a second stop-cock below the burette.

(4) *Stirring-rod.*— The stirrer (D) is so designed that it will maintain a rapid, uniform speed and stir thoroly the volume of milk used without producing excessive foam. The stirring-rod is made of perfectly straight, rigid glass tubing about 1 cm. in diameter, and is mounted on two annular ball-bearings (E and E). The

attachment of the ball-bearings to the glass stirring-rod is made by interposing sections of rubber tubing of suitable thickness. This arrangement has the effect of keeping the stirring-rod properly centered and thus prevents strain on the glass tubing and consequent vibration and foaming. Connection with the motor (M) is conveniently made by means of rubber tubing (R). Such a stirrer, if properly balanced, is found to run at high speed without vibration and is convenient in the laboratory for many other uses. The motor should be connected with a rheostat to control the speed of the stirrer.

As shown in the illustration, the stirrer is placed in the vessel at one side of the center. In this position the blade (F) forces the milk upward. If the stirrer were in the center of the body of milk, the rotation would tend to form a whirlpool and draw air into the milk, resulting in the formation of foam. Moreover, the upward movement of the milk against the tip of the acid-delivery tube causes the most rapid and thorough mixing of the acid and milk.

The tip of the acid-delivery tube is placed, as shown in the illustration, in such a manner in relation to the revolving blade that the whirling milk washes the end of the tip but is not thrown directly against the opening in the tip in such a way as to force milk or particles of casein into the tube, which might result in clogging the tube and stopping the flow of acid.

MILK USED.

Fresh, undiluted milk, the fat of which has been removed by centrifuge, cooled to 15° C., is used. While any amount of milk can be taken by furnishing the required conditions for proper manipulation, the description here given applies, for convenience, to the use of 1 liter of milk.

KIND OF ACID.

While many acids can be used, our work has been limited to the use of acetic, lactic, and hydrochloric acids. Preference, however, as the result of experience in this work, is given either to normal lactic acid or to a mixture consisting of 1 part of normal hydrochloric acid and 1 or 2 parts of normal acetic acid. It has been found that acetic alone does not always give a satisfactory coagulation of casein in undiluted milk. Satisfactory preparations have been made by the use of hydrochloric acid alone. The only objection to its use is the danger of adding too much acid.

ADDITION OF ACID AND COAGULATION OF CASEIN.

To 1 liter of milk, normal acid is added in the apparatus described above, the stirrer rotating as rapidly as possible without causing excessive foaming, which is usually at the rate of 2,000 to 3,000

revolutions per minute. The acid is allowed to flow into the milk at a rate which will not cause appreciable coagulation as shown by application of the following sedimentation test.

A few cc. of the milk are whirled in a sedimentation tube for a short time. If, on pouring the liquid from the tube, a sediment remains at the bottom, it is an indication that acid has been added too rapidly and has caused some coagulation of casein at the point of contact of acid and milk. Such action can also be avoided by having the milk and acid at low temperatures. Generally speaking, the first 45 cc. can be added in 30 minutes. The addition of acid is continued until the amount reaches about 60 cc., after which the rate is decreased somewhat until the coagulation point is nearly reached, as shown by the tests given below; and then, before addition of more acid, the mixture is allowed to stand about 3 hours, the rate of stirring being diminished to 500 revolutions per minute or less. The amount of acid to be added above 45 cc. can be ascertained by taking a sample of the original milk and titrating to the coagulation point, and then adding this amount of acid in the manner above indicated. The use of some brom-cresol purple as indicator aids in detecting the approach to the coagulation point. This can be more accurately ascertained by diluting a few cc. of the acidified milk with an equal volume of distilled water and centrifuging in a sedimentation test-tube, when the casein completely separates. This is due to the fact that the hydrogen ion concentration of acidified milk is increased by dilution and that this increase is sufficient, in case of milk near the point of casein coagulation, to throw down the casein. When this test results in casein separation, the addition of acid is stopped, as stated above. When this test shows no casein separation, then addition of acid is continued and the test repeated at intervals until such separation of casein occurs.

During the latter stages of addition of acid, foaming may make some trouble. This, however, can be obviated or controlled by adding a few drops of octyl alcohol, or by using a stirrer free from vibration, or by having the vessel that contains the milk about double the capacity required to hold the amount of milk used, which will usually provide sufficient room to accommodate the foam; any foam forming subsides promptly when the coagulation of the casein takes place.

After standing under gentle stirring for 3 hours with acidity just below the point of casein coagulation, addition of acid is continued slowly, accompanied as before by rapid stirring in order to obtain the particles of casein coagulum in the finest possible state of division. Addition of acid is now continued to the point at which a portion of the mixture, when centrifuged, gives a definite supernatant layer of solution above the casein. Ordinarily, it requires about 90 cc. of normal lactic acid or of a mixture of 1 part of normal

hydrochloric acid and 2 parts of normal acetic acid to accomplish this for each liter of milk used. Less normal hydrochloric acid (about 75 cc.) is required. When the coagulation is complete, as shown by the test, the mixture is allowed to stand 2 to 4 hours with gentle stirring.

TREATMENT OF CASEIN COAGULUM.

The mixture of coagulated casein and solution is placed in two or four half-liter centrifugal bottles and whirled in a centrifuge at a rate of about 1,000 revolutions per minute until the casein settles at the bottom, occupying about one-third of the original volume of the mixture. The supernatant liquid is decanted. The casein, which is now a white, dense, gelatinous-appearing mass is next washed with distilled water in the centrifugal bottle. In order to mix the water thoroly with the compacted mass of casein, it is necessary to add the water in small amounts and beat the mixture with a rubber-tipped, glass-rod stirrer into a mass of smooth, creamy consistency, free from lumps; enough water is used to bring the mixture to the capacity of the bottle. This mixture of water and casein is centrifuged until the casein is separated as before, and then the supernatant liquid is decanted. The operation of washing with distilled water is repeated until the casein fails to separate completely from the water when the mixture is centrifuged, indicating freedom from electrolytes. This may require four or five washings. After final washing with water and decantation, the casein is washed first with cold 95 per ct. alcohol twice, and then with ether three times, in the same manner as with water, care being taken to add the liquid gradually with vigorous beating, particularly in the first washing with alcohol, in order to make a smooth, homogeneous mixture and prevent aggregations of casein particles. The centrifuging with alcohol and ether does not usually require as long a time as with water. The object of washing with alcohol is to remove the water and any alcohol-soluble material as completely as possible before treating with ether. An excessive amount of water in the casein causes it to cake hard in drying. Washing with ether serves chiefly to remove any fat that remains. A very minute amount of fat in the casein causes a cloudy or milky appearance when the casein is dissolved in excess of lime-water. The casein is finally spread on a smooth, flat surface in the open air to dry. While drying, the mass should be gently worked with a spatula in order to keep it in its finely pulverulent condition.

A second method of washing the coagulated casein can be conveniently used if larger amounts are to be washed than can be accommodated by the capacity of the centrifuge. The coagulated casein prepared in the manner described above is transferred to tall precipitating jars holding 10 to 15 liters. Each jar is filled to about one-fifth of its capacity with casein and then completely filled with

cool distilled water. The finely-divided casein settles in an hour or more and the supernatant liquid is siphoned off. The washing is repeated five or six times and the washed casein finally freed from water as completely as possible in the centrifugal. Alcohol is then added and mixed by beating in as before, care being taken to prevent any lumping of casein particles during addition of alcohol. The formation of lumps in this process is not always easy to prevent; but when lumps do form, they can usually be broken into fine particles again with the stirrer. The mixture can stand over night without disadvantage after the addition of alcohol. The alcohol is then removed by treatment with ether as above described, or, in order to save ether, the casein is washed with alcohol two or three times and then washed once with absolute alcohol, after which it is dried in a vaccuum oven at 45° C. The product thus obtained is in a finely pulverulent condition, containing some fat which can be removed by treatment with petroleum ether. Attention is called to the fact that the essential condition in obtaining a finely-divided product is the removal of all water before and during the process of drying.

CONTROL OF ASH AND PHOSPHORUS CONTENT OF CASEIN.

The ash and phosphorus content of casein prepared in the manner described depends upon certain details in the method of preparation. Holding the casein in the uncoagulated condition at a degree of acidity just below the point of coagulation results in a preparation low in phosphorus, the minimum amount being 0.80 per ct. This result is due to the fact that the suspended inorganic phosphate ($CaHPO_4$) in milk is completely dissolved by the treatment. It requires, in our experience, 3 hours at least to make sure of complete solution of the insoluble phosphate. It is, however, not advisable to let the casein stand in this uncoagulated condition more than 6 hours, especially if not kept at a temperature of 18° C. or lower, because some slight hydrolysis of the casein may occur, which tends to affect unfavorably the properties of the preparation.

If casein after coagulation is held in suspension at a hydrogen ion concentration above the isoelectric point, the amount of ash is low, ranging from 0.05 to 0.15 per ct. This result is due to the decomposition of the calcium caseinate, the acid combining with the calcium and leaving the casein base-free. Complete action requires 2 to 4 hours. Longer standing under these conditions is not likely to cause any hydrolysis, according to our experience. When, therefore, it is desirable for convenience to carry the preparation over night and complete it the second day, the casein can remain in this completely coagulated condition without affecting its character.

When the insoluble inorganic phosphate is not completely dissolved before coagulation, it does not appear possible to remove

it completely after coagulation, no matter how long the mixture is allowed to stand. This is indicated by the results embodied in the following table:

Time of standing before coagulation.	Time of standing after coagulation.	Ash.	Phosphorus.*
Hrs.	*Hrs.*	*Per ct.*	*Per ct.*
0	6	0.15	0.85
0	24	0.14	0.86
0	24	0.15	0.83
3	0	0.46	0.81
4	0	0.43	0.81
1	12	0.15	0.85
3	15	0.05	0.80
3	18	0.11	0.81
4	4	0.10	0.81
16	4	0.10	0.81
30	10	0.10	0.80

* We are indebted to Mr. R. F. Keeler for repeating and confirming these determinations.

The first three series of results in the table show that when the mixture is not allowed to stand awhile in the uncoagulated condition at a point of acidity just short of coagulation, the phosphorus content is relatively high. The cases in which the mixture was allowed to stand 3 and 4 hours before coagulation, but not at all after, show high ash but low phosphorus content, indicating removal of inorganic phosphorus and retention of calcium in the form of calcium caseinate. The last five series of results in the table, from preparations obtained by allowing the mixture to stand 3 to 30 hours before coagulation and 4 to 18 hours after, show a minimum of both ash and phosphorus. In no case was it found possible to obtain a preparation with a percentage of phosphorus lower than 0.80 by prolongation of the period of standing.

ADVANTAGES OF METHOD OF MAKING PREPARATION OF CASEIN.

In comparing the method described in this article with other methods employed for the preparation of casein, there are certain facts in favor of the new method, to which attention is called.

1. By the new method a preparation of casein can be made within 10 hours. Other methods usually require 2 or 3 days.

2. This method uses the milk without dilution and saves much time and labor in lessening the amount of material to be handled.

3. In this method unnecessary excess of acid is avoided. The hydrogen ion concentration of the coagulation mixture is only

slightly above the isoelectric point of casein; that is, about pH 4.5 to 4.6.

4. The contact with reagents need not exceed 6 to 8 hours.

5. At no time is the casein brought into contact with alkali.

6. The casein thus prepared is base-free, containing no calcium phosphate and no form of calcium caseinate.

7. The dried casein we obtain forms a very fine powder even without grinding; usually about 90 per ct. will pass a screen containing 100 meshes to the inch.

8. This casein very easily and quickly dissolves to a water-clear solution in dilute mono-basic alkali solutions and also in excess of lime-water. Lime-water solutions of the casein, when neutral, are opalescent.

9. By this method it is possible to obtain without appreciable loss all the casein in the milk in pure form. In other methods the losses of casein in manipulation are considerable and unavoidable.

II. A METHOD FOR MAKING ELECTROMETRIC TITRATIONS OF SOLUTIONS CONTAINING PROTEINS.

JOHN C. BAKER AND LUCIUS L. VAN SLYKE.

While carrying on an investigation relating to the amount of free lactic acid present in milk during the process of souring (see p. 249), we found it desirable to make many electrometric titrations, giving accurate results, with solutions containing milk proteins, for the purpose of obtaining numerous data to be used in preparing a curve for each series of titrations. The methods previously used for this purpose[1-7] in connection with proteins have involved the preparation of a separate solution and the replating of the electrode for each point in a curve. Such a procedure requires large expenditure of time, labor, and material and, moreover, gives inaccurate results when the proteins coagulate.

We have undertaken to devise a method by which electrometric titrations can be accurately performed in one solution. Hildebrand [8] has proposed a method which partially accomplishes this purpose but the results obtained are of only approximate accuracy, and, moreover, the method is not applicable to solutions containing protein. McClendon [9] has recently published a method of continuous electrometric titration, which, however, cannot be used in the presence of proteins that are precipitated by the titration reagent or on the electrode, especially at the point of contact at the surface of the liquid.

APPARATUS.

The apparatus used by us in making numerous electrometric titrations in one solution consists of several essential parts, as shown in Fig. 2. The new features devised by us relate to the assemblage of the different parts in the vessel in which the reaction takes place and to the arrangement of the electrode. The other parts of the apparatus are the tube carrying the standard acid into the solution, the tube for introducing special reagents, the stirrer, and the tube carrying the saturated KCl solution.

(*1*) *Vessel holding protein solution.*— The vessel (V) in which the electrode is placed and in which the reaction occurs is a wide-

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[1] Bugarszky, S., and Liebermann, L., *Arch. ges. Physiol.*, 72:51, 1898.
[2] Robertson, T. B., *J. Physic. Chem.*, 14:528, 1910.
[3] Manabe, K., and Matula, J., *Biochem. Z.*, 52:369, 1913.
[4] Pauli, W., and Hirschfeld, M., *Biochem. Z.*, 62:245, 1914.
[5] Clark, W. M., *J. Med. Research*, 31:431, 1914–5; *J. Infect. Dis.*, 17:109, 1915.
[6] Schmidt, C. L. A., *J. Biol. Chem.*, 25:63, 1916.
[7] Cullen, G. E., *J. Biol. Chem.*, 30:371, 1917.
[8] Hildebrand, J. H., *J. Am. Chem. Soc.*, 35:847, 1913.
[9] McClendon, J. F., *J. Biol. Chem.*, 33:19, 1918.

mouthed bottle. It may be of any size adapted to one's convenience but should have about twice the capacity of the liquid to be used. In our work we have found it convenient to take 100 cc. or 200 cc. of solution, and we therefore use a bottle holding about 400 cc., calibrated in units of 50 cc. The apparatus is so arranged that it can be used in a water-bath if desired.

The neck of the bottle is provided with an easy-fitting cork stopper (S), thru which pass into the bottle the several parts or connections of the apparatus. For greatest convenience this

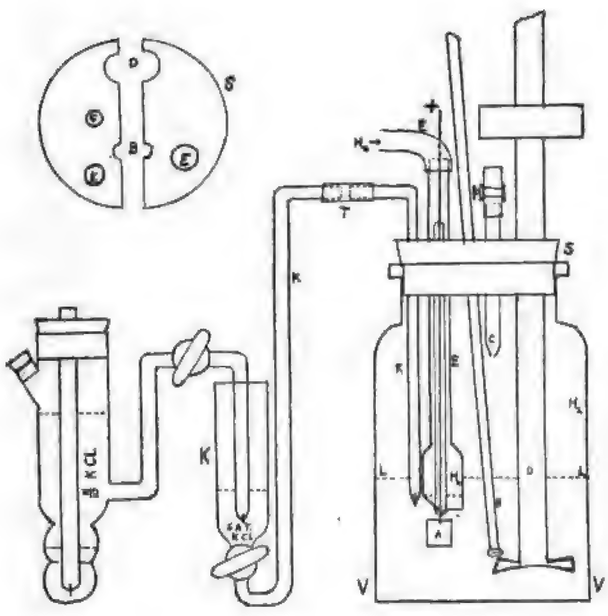

FIG. 2

stopper is divided into two equal parts, as shown in the illustration, with perforations as indicated. This arrangement simplifies the assemblage of the parts of the apparatus.

(2) *Hydrogen electrode.*— The hydrogen electrode (A) is suspended inside the *hydrogen-carrying tube* (E). The latter is made from a 10 cc. pipette, which is cut in two in the middle, and the lower part of one side is cut off diagonally, thus forming a bell-shaped projection at the lower end, which is used for the protection of the hydrogen electrode when the parts of the apparatus are being put together. The upper end of this hydrogen tube passes thru a hole (E) in the stopper, being fitted so that it can be

raised and lowered, thus permitting the lower end to be raised above, or submerged below, the surface (L–L) of the solution in the vessel, according as it is desired or not to allow hydrogen to bubble thru the solution. The tube is connected at the upper end with the hydrogen supply by means of pure gum rubber tubing, which must make gas-tight joint connections.

The hydrogen electrode (A) consists of a piece of platinum foil about 1 cm. square, welded to a platinum wire about 15 cm. long. The lower half of the wire is protected by enclosure in a piece of glass tubing about 8 cm. long, reaching close to the electrode, and is sealed by fusion at each end. This protecting glass tube must be small enough to pass freely inside the hydrogen tube (E) in order to permit raising and lowering and also to allow the free passage of hydrogen.

In order to arrange the hydrogen electrode properly inside the hydrogen tube, the rubber tubing at the upper end of the hydrogen tube is pulled across the end of the tube and punctured with a pin; through the hole thus made the upper end of the wire on the platinum electrode is passed making a gas-tight sliding joint. The wire end of the electrode is introduced into the lower or bell-shaped end of the hydrogen tube and is then passed thru the pin-hole made in the rubber tubing. The electrode can now be raised or lowered within the hydrogen tube by taking hold of the portion of the wire extending above the rubber tubing. When the electrode is raised so as to be within the bell-shaped projection of the hydrogen tube, it is completely protected from the outside, but it must not touch the inside walls of the bell at any point.

Before using, the electrode is cleaned in hot chromic acid, washed with water, and given a uniform coating of platinum black.[10] It is then dipped again in hot chromic acid, washed, and electrolyzed according to Clark's directions. The bubbles should come from the electrode at all points with perfect uniformity. When this test is satisfactorily met, the electrode is drawn up into the bell and placed in a beaker of distilled water to soak for not less than half an hour, after which it is ready for use. Electrodes thus prepared rarely fail to give satisfactory results. If it is desired to check specially the accuracy of an electrode before using, this is done by any of the standard solutions such as Sörensen's phosphate mixture[11] or Clark's standards.[12]

(*3*) *Glass tube carrying titration reagent.*— The capillary glass tube (B), which carries the titration reagent from a burette into the solution in the vessel, has been previously described on p. 7. A burette 30 cm. long and holding 10 cc. can be used to advantage.

[10] Clark, W. M., *J. Biol. Chem.*, 23:475, 1915.
[11] Sörensen, S. P. L., *Ergebn. Physiol.*, 12:393, 1912.
[12] Clark, W. M., and Lubs, H. A., *J. Biol. Chem.*, 25:479, 1916.

The hole in the cork thru which B passes should be sufficiently close-fitting to hold it firmly.

(4) *Stirring-apparatus.*— The stirring-apparatus (D) has been already described by us on p. 7. The stirring-rod should not fit too closely in the opening in the cork stopper thru which it passes but should be allowed room enough for free movement.

(5) *Tube for introducing special reagents.*— The special tube (C) is ordinary glass tubing about 2 inches long, which can be used for the introduction of any special reagent that may be desired, such, for example, as caprylic alcohol, when necessary, to prevent foaming. To the upper end of this tube is fitted a piece of rubber tubing, provided with a clamp with which to keep the tube closed when not in actual use for admitting a reagent. By making this tube long enough to reach below the surface of the solution, it can be used for withdrawing solution when desired. In this case the tube should be located near the side-wall of the bottle away from the stirrer.

(6) *Tube containing KCl.*— The tube (K) containing saturated KCl solution consists of a small cylindrical funnel-tube fitted with a glass stop-cock and bent in the manner shown in the illustration. For convenience in handling, the tube is divided at the top (T), and the two separate parts are connected closely with rubber tubing. In case the apparatus is used with a water-bath, the stop-cock should be located near the rubber connection. The end of the tube where it dips into the protein-containing solution in the bottle, is drawn out to make the opening small and this opening is plugged with a small roll of filter paper to retard the flow and diffusion of the KCl solution. If desired, the saturated solution of KCl can be held in the tube with agar. The level of the KCl solution in the cylindrical funnel must be slightly below that of the liquid (L–L) in the bottle in order to prevent flow. A balance of the solutions is desirable. This tube is fitted in the cork stopper so that it can be raised in order to remove the lower end from the solution. The stop-cock should be closed when the tube is being raised.

(7) *Additional pieces of apparatus.*— In making electrometric titrations, the following additional pieces of apparatus are used. (*a*) A Leeds and Northrup potentiometer, type K; (*b*) a Leeds and Northrup galvanometer, type R, for zero instrument; (*c*) a one cell storage battery to supply the working current, which is checked with a Weston standard cell kept at constant temperature. The current being measured originates in the chain, Hg | HgCl | 0.1 N KCl | saturated KCl | solution | H_2 | Pt |, kept at constant temperature during each titration.

ADVANTAGES OF APPARATUS.

In addition to the points of convenience already mentioned, the special arrangement of the apparatus in the vessel (V), described

above, enables one to overcome certain difficulties that are commonly encountered in making electrometric titrations, such as interference by dissolved oxygen, local chemical action at the point where the titration reagent is introduced into the solution titrated, foaming of solution, deposition of protein on electrode, and interference by bacterial action or by autohydrolysis during titration. These difficulties have been satisfactorily overcome.

(*1*) *Interference by dissolved oxygen.*— This is prevented by displacing the air from the vessel (V) and maintaining a slow current of hydrogen thru it.

(*2*) *Local chemical action.*— Chemical action at the point where the reagent is introduced into the solution is prevented by using the specially designed tip and stirrer described by us on p. 7. The use of the stirrer has been found to be of service also in overcoming some of the other difficulties.

(*3*) *Foaming of solution.*— This is a troublesome feature connected with the titration of solutions containing protein. The mechanical stirrer tends to increase the difficulty. It is overcome by introducing the hydrogen above the surface of the solution to be titrated and also by controlling the vibration and speed of the stirrer. While the foaming is thus kept at a minimum, yet enough hydrogen is stirred into the solution to keep the electrode saturated. In case foaming is not troublesome, the hydrogen can be introduced under the surface of the solution in the manner indicated in the illustration. With solutions that foam easily, caprylic alcohol can be used effectively [13] and without interfering with the accuracy of the results of titration. However, its use is advocated only as a last resort.

(*4*) *Deposition of protein on electrode.*— This can be prevented by complete immersion of the electrode in the solution. The rapid movement of the solution prevents local chemical action at the electrode and at the same time hydrogen is stirred into the solution and carried to the electrode. However, other precautions to prevent deposition of protein are essential. The platinum wire attached to the electrode must be protected at the point where it enters the solution, which is accomplished by sealing it into the glass tube, as already described. The electrode after being plated must be soaked in distilled water for a half hour or more before being used, in order to remove adsorbed acid. The apparatus is so arranged that the electrode can be quickly lowered into the solution after the parts of the apparatus are assembled and the stirrer started to rotating. This arrangement prevents collection of protein on the electrode.

(*5*) *Bacterial action and autohydrolysis.*— Interference from these actions can be satisfactorily prevented only by fairly rapid work. We have been able within 2 hours to complete determinations yield-

[13] Van Slyke, D. D., *J. Biol. Chem.*, 12:282, 1912.

ing values for use in making a curve, and during such a brief period of time no appreciable interference takes place due to changes caused by these agencies. We have found no antiseptic wholly free from objection when used in the solution under examination. Of those tried, thymol has been found the least objectionable.

OPERATION.

The solution to be titrated is poured into the bottle or vessel (V) and water is added to make the desired volume. If a thermostat is used, the temperature of the solution should now be adjusted. Any bubbles present should be removed, which can be done by pricking them with a greased pin or by touching them with a fine capillary tube containing ether. The burette must be previously filled and all bubbles carried out of the delivery tube (B), the tip of which should be rinsed before it is put into the vessel. The filled delivery tube and the stirrer are placed in position within the vessel or bottle. The two halves of the cork stopper are now placed in position together with the other parts. Care is taken to have the electrode drawn up within the protecting bell so that it does not touch the apparatus or solution. Hydrogen is now permitted to flow rapidly in until the air is displaced, after which the stirrer is set in motion. This precaution is necessary because any bubbles of air that are stirred into the solution greatly retard the attainment of equilibrium. The electrode is now quickly lowered until it is entirely under the surface of the solution, and connections are then completed for the electrolytic circuit. Equilibrium is quickly reached ordinarily, usually in 2 to 5 minutes after introducing the electrode. During the period approaching equilibrium, the stirrer should be run fast enough to keep a few bubbles of hydrogen constantly in suspension in the solution. Equilibrium is indicated by a constant E. M. F. for 2 minutes or more. When the E. M. F. is satisfactory, the desired amount of reagent is slowly introduced from the burette, during which the stirrer may be slightly accelerated to prevent coagulation but not fast enough to produce foam. After introduction of the reagent, readings are made once a minute until constant. When the amount of reagent introduced is 0.5 cc. or less, equilibrium should be immediate. Titration is now continued until the desired number of values is obtained.

In order to avoid marked dilution of the protein solution, titrations are made with use of N solutions of reagents, and thus the need of making corrections is avoided since the hydrogen ion concentration of the buffered solutions is inappreciably changed by the small degree of dilution under such conditions. The speed of the stirrer must be carefully regulated so as to cause little or no foam; consequently, the addition of the reagent must be moder-

ately slow; for example, about 1 cc. in 2 minutes in the case of N HCl with solutions containing 1 per ct. of casein.

The accuracy of the electrometric titration can be checked, when completed, by redetermining the final E. M. F. value of the titration of the solution with a Clark electrode. If agreement is not close, the results of the titration should be discarded and the operation repeated. In our work agreement is nearly always obtained.

III. FREE LACTIC ACID IN SOUR MILK.

LUCIUS L. VAN SLYKE AND JOHN C. BAKER.

INTRODUCTION.

It has been the universal custom to speak of the acid constituents present in sour milk as lactic acid, just as if the acidity were due directly and entirely to the presence of free lactic acid, as such. The usual method of determination has been to titrate the milk to phenolphthalein with 0.1 N alkali and to express the results either as percentage of lactic acid or as the number of cc. of 0.1 N alkali required to neutralize 100 cc. of milk.

When milk sours under ordinary conditions, lactic acid is first formed but this reacts at once, practically as fast as formed, with the basic constituents present in the milk.[1] In fresh cow's milk, the compounds reacting with acids are, first, basic phosphates and citrates of calcium, magnesium, sodium, and potassium, and second, calcium caseinate.[2] When the lactic acid that is formed in the souring of milk reacts with these compounds, there are formed mono-basic or acid phosphate and citrate salts, free casein, and lactate salts, especially of calcium. It is sufficient for our purpose to represent more simply the essential results of the reactions as consisting of the formation of mono-calcium phosphate, free casein, and calcium lactate. In view of this condition, it cannot be expected that there will be considerable amounts of free lactic acid in souring milk until these reactions are practically completed.

In previous work carried on in this laboratory, efforts were made to determine separately the amounts of free lactic acid and combined lactic acid. It was found, however, in a solution containing lactic acid, that lactates and mono-basic phosphates undergo mutual reaction, forming free lactic acid and di-calcium phosphate. It was impossible to tell with accuracy at what point the conversion of lactate into free lactic acid begins, and no satisfactory method by continuous extraction has been found for making a separate determination of free lactic acid in the presence of lactate and phosphate salts.

In the work described in this article, three methods have been used for determining the amount of free lactic acid in sour milk. In two of these methods, the results are based largely upon the measurement of hydrogen ion concentration (C_H) and in the other upon partial extraction of lactic acid by ether. In addition, it has

[1] Van Slyke, L. L., and Bosworth, A. W., N. Y. Agrl. Expt. Sta. Tech. Bul. 48, 1916, and *Jour. Biol. Chem.*, 24: 191, 1916.

[2] Van Slyke, L. L., and Bosworth, A. W., N. Y. Agrl. Expt. Sta. Tech. Bul. 39, 1914, and *Jour. Biol. Chem.*, 20: 135, 1915.

been necessary to make a study of the influence exerted by adsorption of lactic acid by casein. Further work is presented in relation to the effect of different conditions upon the amount of free lactic acid in sour milk, the coagulation point of casein in sour milk, and the first indications of sour flavor in milk.

SOME ELEMENTARY FACTS REGARDING HYDROGEN ION CONCENTRATION.

Before presenting the results of our work, it is desirable to consider some fundamental facts in relation to the meaning of hydrogen ion concentration for the benefit of those readers who are not familiar with the developments of physical chemistry.

Salts, acids and bases in water solution owe their characteristic activities to the fact that the compound in each case exists not as an integral molecule but is separated into constituent parts; and the extent to which this separation takes place determines the chemical characteristics of the dissolved substance.

Thus, for example, acids in solution owe their characteristic chemical properties to their free hydrogen ions. An acid in water solution is to be regarded, so far as its activity is concerned, not as the entire, intact molecule, but as split up into two parts, (1) hydrogen ion (H^+) and (2) acid radical; and the active characteristics of an acid in water solution depend very largely upon the extent to which the molecule undergoes dissociation or separation into hydrogen ion and acid radical. This fact has been recognized in a practical way by speaking of acids as strong or weak. Strong acids, such for example as hydrochloric, are those which are distinguished for their vigor of chemical activity, due to the fact that the hydrogen ions are, in large part, free. Weak acids, such for example as acetic, are distinguished for the mildness of their chemical activity, which is due to the fact that only a relatively small proportion of the hydrogen ion content is free.

Similarly, basic compounds, such as hydroxides, are regarded as consisting of two parts, (1) hydroxyl ion (OH^-) and (2) base; and the chemical activity of a base in water solution is dependent upon the extent to which the compound is split into these two parts. Such compounds are regarded as weak or strong bases according to the proportion of free hydroxyl ions.

The chemical terms, *neutrality*, *acidity* and *alkalinity*, can be defined quantitatively in terms of ions of hydrogen and hydroxyl, as we shall point out.

(1) A solution is *neutral* when the number of free hydrogen ions is the *same as* that of the free hydroxyl ions ($H^+ = OH^-$).

(2) A solution is *acid* when the number of free hydrogen ions is *greater than* that of the free hydroxyl ions ($H^+ > OH^-$).

(3) A solution is *alkaline* when the number of free hydrogen ions is *less than* that of the free hydroxyl ions ($H^{+} < OH^{-}$).

It is not necessary for our purpose to describe here the method used in making measurement of the number of free hydrogen ions or hydrogen ion concentrations. It is, however, essential to consider the method of expressing quantitatively the results of such measurements.

In stating specific amounts of acids or alkalis in analytical chemistry, we use as our standard of concentration or " strength " the normal solution, which is defined as a solution containing the equivalent of one gram of hydrogen in one liter of solution. Hydrogen ion concentration can be expressed quantitatively in two ways: (1st) In terms of normal solution or hydrogen ion normal (C_H), and (2nd) in the form of the symbol, pH. Each of these expressions has its advantages and objectionable features. For those who have always been accustomed to express acidity and alkalinity in terms of the normal solution, it is extremely awkward to interpret pH values in relation to the reactions of solutions. This is owing to the fact that the mathematical method of obtaining the values of pH is such that the higher the figure representing the value of pH, the lower is the hydrogen ion concentration. Thus, an increase in the value of pH indicates a decrease in the hydrogen ion concentration. It is, therefore, important to understand the meaning of the value of pH more fully in relation to neutrality, acidity and alkalinity as commonly expressed.

In pure water, the concentration of hydrogen ions is equal to that of hydroxyl ions. Therefore, as a starting point, pure water is regarded as a really neutral solution, or, stated in another way, the hydrogen ion concentration of pure water is believed and is taken to be that of true or absolute neutrality. Consequently, the concentration of hydrogen or of hydroxyl ions in pure water is called the *true or absolute neutral point*. Now, by actual measurement, the hydrogen ion concentration of pure water, expressed in terms of normal solution (C_H) is known to be .000,000, 1 N, or, expressed more conveniently in abbreviated form, 1×10^{-7} N; and this value represents quantitatively the true or absolute neutral point. On this basis, solutions are *acid* when they contain hydrogen ion concentrations greater than, or hydroxyl ion concentrations less than, 1×10^{-7} N; and solutions are *alkaline* when they contain hydrogen ion concentrations less than, or hydroxyl ion concentrations greater than, 1×10^{-7}.

Further, when expressed in terms of pH, the hydrogen ion concentration of pure water (1×10^{-7} N) has a value of 7. In the scale of pH values, 7 is therefore the true neutral point, and all values greater than 7 indicate alkaline solutions, while all values less than 7 indicate acid solutions.

TABLE A.— HYDROGEN ION CONCENTRATION EXPRESSED IN FORM OF

Values of pH.	Values of C_H (the hydrogen ion normal or normal solution). Abbreviated form.	Full form.	Reaction.
1.0	0.1×10^{-0}	=.10N	Acid
1.1	0.8×10^{-1}	=.08N	"
1.4	0.4 " "	=.04N	"
1.7	0.2 " "	=.02N	"
2.0	0.1 " "	=.01N	"
2.1	0.8×10^{-2}	=.008N	"
2.4	0.4 " "	=.004N	"
2.7	0.2 " "	=.002N	"
3.0	0.1 " "	=.001N	"
3.1	0.8×10^{-3}	=.000,8N	"
3.4	0.4 " "	=.000,4N	"
3.7	0.2 " "	=.000,2N	"
4.0	0.1 " "	=.000,1N	"
4.1	0.8×10^{-4}	=.000,08N	"
4.4	0.4 " "	=.000,04N	"
4.7	0.2 " "	=.000,02N	"
5.0	0.1 " "	=.000,01N	"
5.1	0.8×10^{-5}	=.000,008N	"
5.4	0.4 " "	=.000,004N	"
5.7	0.2 " "	=.000,002N	"
6.0	0.1 " "	=.000,001N	"

				Hydrogen Ion Concentration Expressed in Form of		
6.1	0.8×10^{-6}	=.000,000,8N	"			
6.4	0.4 " "	=.000,000,4N	"			
6.7	0.2 " "	=.000.000,2N	"			
7.0	0.1 " "	=.000,000,1N	Neutral	Values of pH	Values of C_{OH} (the hydrogen ion normal or normal solution)	
7.1	0.8×10^{-7}	=.000,000,08N	Alkaline	7.1	0.125×10^{-6}	=.000,000,125N
7.4	0.4 " "	=.000,000,04N	"	7.4	0.250 " "	=.000,000,25N
7.7	0.2 " "	=.000,000,02N	"	7.7	0.500 " "	=.000,000,5N
8.0	0.1 " "	=.000,000,01N	"	8.0	1.000 " "	=.000,001N
8.1	0.8×10^{-8}	=.000,000,008N	"	8.1	0.125×10^{-5}	=.000,001,25N
8.4	0.4 " "	=.000,000,004N	"	8.4	0.250 " "	=.000,002,5N
8.7	0.2 " "	=.000,000,002N	"	8.7	0.500 " "	=.000,005N
9.0	0.1 " "	=.000,000,001N	"	9.0	1.000 " "	=.000,01N
9.1	0.8×10^{-9}	=.000,000,000,8N	"	9.1	0.125×10^{-4}	=.000,012,5N
9.4	0.4 " "	=.000,000,000,4N	"	9.4	0.250 " "	=.000,025N
9.7	0.2 " "	=.000,000,000,2N	"	9.7	0.500 " "	=.000,05N
10.0	0.1 " "	=.000,000,000,1N	"	10.0	1.000 " "	=.000,1N
10.1	0.8×10^{-10}	=.000,000,000,08N	"	10.1	0.125×10^{-3}	=.000,125N
10.4	0.4 " "	=.000,000,000,04N	"	10.4	0.250 " "	=.000,25N
10.7	0.2 " "	=.000,000,000,02N	"	10.7	0.500 " "	=.000,5N
11.0	0.1 " "	=.000,000,000,01N	"	11.0	1.000 " "	=.001N
11.1	0.8×10^{-11}	=.000,000,000,008N	"	11.1	0.125×10^{-2}	=.001,25N
11.4	0.4 " "	=.000,000,000,004N	"	11.4	0.250 " "	=.002,5N
11.7	0.2 " "	=.000,000,000,002N	"	11.7	0.500 " "	=.005N
12.0	0.1 " "	=.000,000,000,001N	"	12.0	1.000 " "	=.01N
12.1	0.8×10^{-12}	=.000,000,000,000,8N	"	12.1	0.125×10^{-1}	=.012,5N
12.4	0.4 " "	=.000,000,000,000,4N	"	12.4	0.250 " "	=.025N
12.7	0.2 " "	=.000,000,000,000,2N	"	12.7	0.500 " "	=.05N
13.0	0.1 " "	=.000,000,000,000,1N	"	13.0	1.000 " "	=.10N

In order to enable one to compare easily the values furnished by these two methods of expressing hydrogen ion concentration, we have prepared table A, giving the equivalent values of hydrogen ion concentration for pH values varying from 1 to 13 and also of hydroxyl ion concentrations for pH values varying from 7 to 13.

The first column in the table gives figures for pH values varying from 1 to 13; the second and third columns show the equivalent values of hydrogen ion concentrations expressed in terms of the hydrogen ion normal (C_H) or normal solution, the abbreviated form being given in the second column and the full form, expressed decimally, in the third column. In the fourth column the character of the reaction is stated. In case of pH values higher than 7, the equivalent values are given for hydroxyl ion normal (C_{OH}) or normal solution in columns six and seven.

In order to bring out a simple relation existing between the pH values and their equivalent expressed in terms of hydrogen ion and hydroxyl ion normal, pH values are taken at intervals of 0.3 in most cases. It will then be observed that the following rules apply with close approximation when we take any two points in the range of pH values differing by 0.3:

(1) A decrease of 0.3 in the value of pH at any point is equivalent to doubling the C_H value at that point.

(2) An increase of 0.3 in the pH value at any point is equivalent to halving the C_H value and doubling the C_{OH} value, at that point.

For example, when the pH value equals 2, the equivalent C_H value is 0.01; when pH decreases 0.3, that is, to 1.7, C_H equals 0.02. Again, when the value of pH equals 7.1, the C_H value is 0.8×10^{-7}; when pH increases 0.3, that is, becomes 7.4, the C_H value is 0.4×10^{-7}. At the same point (pH, 7.1), the C_{OH} value is $.125 \times 10^{-6}$; when the value of pH increases to 7.4, the equivalent C_{OH} value is $.250 \times 10^{-6}$.

It is obvious that the use of the simple numbers representing pH values is more convenient than the numbers representing C_H or C_{OH} values. It is evident also that when one desires to plot hydrogen ion concentration figures upon co-ordinate paper, the pH values possess a marked advantage over the other form of expression, especially when the range of differences in values is large.

Table A will be found useful for those who have been accustomed to think, not in terms of pH values, but only in those of hydrogen or hydroxyl ion normal. It can be seen that the pH value of 1 is approximately represented, for example, by tenth-normal (0.1 N) hydrochloric acid; while the pH value of 13 is represented by tenth-normal sodium hydroxide.

Many are accustomed to express the concentration of solutions only in fractional form, as, for example, $\frac{N}{10}$ instead of the decimal form, .1N. For such, the relations of pH values to the various con-

centrations of solutions can be brought out more clearly by the following illustrations, using Hcl and NaOH and assuming that they are completely ionized:

pH Values	HCl Concentrations Expressed		pH Values	NaOH Concentrations Expressed	
	Decimally	Fractionally		Decimally	Fractionally
1.0	.1 N	$\frac{N}{10}$	8	.000,001 N	$\frac{N}{1,000,000}$
1.4	.04 N	$\frac{N}{25}$	9	.000,01 N	$\frac{N}{100,000}$
1.7	.02 N	$\frac{N}{50}$	10	.0001 N	$\frac{N}{10,000}$
2.0	.01 N	$\frac{N}{100}$	11	.001 N	$\frac{N}{1000}$
2.1	.008 N	$\frac{N}{125}$	11.1	.00125 N	$\frac{N}{800}$
2.4	.004 N	$\frac{N}{250}$	11.4	.0025 N	$\frac{N}{400}$
2.7	.002 N	$\frac{N}{500}$	12.0	.01 N	$\frac{N}{100}$
3.0	.001 N	$\frac{N}{1000}$	12.1	.0125 N	$\frac{N}{80}$
4.0	.0001 N	$\frac{N}{10,000}$	12.4	.025 N	$\frac{N}{40}$
5.0	.000,01 N	$\frac{N}{100,000}$	12.7	.05 N	$\frac{N}{20}$
6.0	.000,001 N	$\frac{N}{1,000,000}$	13.0	.1 N	$\frac{N}{10}$

In Table B we give the pH values and their equivalent C_H values for each 0.01 pH, ranging between 1 and 2. By the use of this table one can readily ascertain values intermediate between those given in Table A. These intermediate figures can be used for any part of the range of values given in Table A by adapting the decimal properly. By the use of Tables A and B in combination, one can convert pH values into C_H values, or vice versa, simply by inspection and without calculation.

TABLE B.— INTERMEDIATE pH AND C_H EQUIVALENTS FOR USE WITH TABLE A.

pH values.	C_H values.	pH values.	C_H values.	pH values.	C_H values.	pH values.	C_H values.	pH values.	C_H values.
1.00	.1000	1.20	.0632	1.40	.0400	1.60	.0251	1.80	.0159
1.01	.0980	1.21	.0619	1.41	.0392	1.61	.0246	1.81	.0156
1.02	.0959	1.22	.0606	1.42	.0384	1.62	.0241	1.82	.0152
1.03	.0939	1.23	.0592	1.43	.0375	1.63	.0236	1.83	.0149
1.04	.0918	1.24	.0579	1.44	.0367	1.64	.0231	1.84	.0146
1.05	.0898	1.25	.0566	1.45	.0359	1.65	.0226	1.85	.0143
1.06	.0877	1.26	.0553	1.46	.0351	1.66	.0220	1.86	.0139
1.07	.0856	1.27	.0540	1.47	.0343	1.67	.0215	1.87	.0136
1.08	.0836	1.28	.0526	1.48	.0334	1.68	.0210	1.88	.0133
1.09	.0815	1.29	.0513	1.49	.0326	1.69	.0205	1.89	.0129
1.10	.0795	1.30	.0500	1.50	.0318	1.70	.0200	1.90	.0126
1.11	.0779	1.31	.0490	1.51	.0311	1.71	.0196	1.91	.0123
1.12	.0762	1.32	.0480	1.52	.0305	1.72	.0192	1.92	.0121
1.13	.0746	1.33	.0470	1.53	.0298	1.73	.0188	1.93	.0118
1.14	.0730	1.34	.0460	1.54	.0291	1.74	.0184	1.94	.0116
1.15	.0714	1.35	.0450	1.55	.0285	1.75	.0180	1.95	.0113
1.16	.0697	1.36	.0440	1.56	.0278	1.76	.0175	1.96	.0110
1.17	.0680	1.37	.0430	1.57	.0271	1.77	.0171	1.97	.0108
1.18	.0665	1.38	.0420	1.58	.0264	1.78	.0167	1.98	.0105
1.19	.0648	1.39	.0410	1.59	.0258	1.79	.0163	1.99	.0103
1.20	.0632	1.40	.0400	1.60	.0251	1.80	.0159	2.00	.0100

There are two points in connection with the determination of hydrogen ion concentration to which it is desirable to call attention briefly: (1) Buffer effects and (2) the relation of hydrogen ion concentration to titration values.

(*1*) *Buffer effects.*— It has been found that many compounds have the property of affecting the results of the determination of the hydrogen ion concentration. When acid or alkali is added to a solution containing such compounds, the change in hydrogen ion concentration is found to be less than would be expected for the known amount of acid or alkali added. Any substance which tends to prevent change in the original hydrogen ion cocentration of its solution, when an acid or base is added, is called a buffer or regulator. Proteins, salts, etc., may exercise such an effect. These effects must be determined for individual cases under specific conditions of concentration, temperature, etc. In the case of milk, the compounds acting as buffers are proteins, phosphates, citrates and carbonates.

(*2*) *Relation of hydrogen ion concentration to titration values.*— We have seen that hydrogen ion concentration is a quantitative measure of the true acidity or alkalinity of a solution. The following question suggests itself to those who have used only titration methods for such measurements: What relations have the values determined by the measurement of the hydrogen ion concentration to those determined by titration? Without going into the full details, it is sufficient for our purpose to state that the neutral point of a solution,

as determined by the use of an indicator, varies according to the indicator used and rarely coincides with the true neutral point shown by the hydrogen ion concentration. For example, phenolphthalein under favorable conditions gives the neutral point of solutions as being somewhere between pH, 8 (C_H, 1×10^{-7}) and pH, 10 (C_H, 1×10^{-9}), instead of at pH, 7 (C_H, 1×10^{-6}); methyl red, between pH, 4 (C_H, 1×10^{-3}) and pH, 6 (1×10^{-5}). It should be stated also that the determination of hydrogen ion concentration shows extremely minute changes in the reaction of a solution, degrees of change which are not appreciable or measurable by the use of an indicator.

METHODS FOR THE DETERMINATION OF FREE LACTIC ACID IN SOUR MILK.

I. MEASUREMENT OF C_H AND APPLICATION OF MASS LAW.

The free lactic acid that is formed in the souring of milk consists, in part, of ionized and, in part, of un-ionized acid. The ionized, or chemically active portion, combines promptly with the basic constituents of the milk to form lactate, as already pointed out. In accordance with the law of mass action, when a portion of ionized acid is thus removed, a portion of the un-ionized or non-dissociated acid changes into the ionized form, and this change goes on continuously during the process of souring. The amount of ionized lactic acid present at any stage of the souring process is very small in comparison with the un-ionized portion, as shown in Table I.

The lactic acid in sour milk is present, therefore, as free lactic acid and combined lactic acid or lactate, the free lactic acid being present as ionized and un-ionized acid. In accordance with the law of mass action, there exist, under the conditions present in sour milk, definite quantitative relations between the amounts of free lactic acid, ionized lactic acid, and combined lactic acid. Our problem is to make use of these mathematical relations in ascertaining the amount of free lactic acid in sour milk at any stage of the souring process. These relations can be expressed by the following equation: $\frac{a(b-x)}{x} = k_t$, in which a equals the hydrogen ion concentration (C_H) or ionized lactic acid; b, the total amount of lactic acid formed; x, the amount of un-ionized free lactic acid; and kt, a constant varying with temperature. In this equation, a is ascertained directly by the measurement of the C_H value; b is found by titration; and kt ($t = 25°$ C.) is about 25 or 26×10^{-5}, as determined by us. Therefore, all the values are known except that of x, the amount of free lactic acid, the value of which is the one we wish to determine. The equation being rearranged becomes $x = \frac{ab}{a + (25 \times 10^{-5})}$.

The value of *a* (C_H) is determined by means of the hydrogen electrode at 25° C., using Cullen's modification of the Clark cell[3], [4] of 2 cc. capacity, with 0.1 N KCl, calomel half-cell, and saturated KCl for contact. A Weston cell, calibrated by the U. S. Bureau of Standards, is used in conjunction with a 2-volt storage battery as standard voltage. All of the apparatus is kept in an air-bath at 25° C. The hydrogen used is purchased in stored cylinders and purified by passing thru strong solutions of alkaline $KMnO_4$ (twice), and alkaline pyrogallol (twice), then dilute H_2SO_4, and finally thru a long tube filled with absorbent cotton. The voltage is read with a Leeds and Northrup potentiometer, with a sensitive galvanometer for zero instrument.

The value of *b*, the total amount of lactic acid formed at any stage in the souring process, is determined by titration to phenolphthalein with 0.1 N NaOH; the figure thus obtained is corrected by the subtraction of the titration value given by the fresh milk.

The value of *k* at 25° C. is determined with the hydrogen electrode, using a solution of pure lactic acid of known concentration and also solutions of lactic acid containing different amounts of calcium lactate. *k* is found to have the same value with or without calcium lactate. This method is used in preference to conductivity methods because it is desired to use the constant in making interpretation of the results obtained by the same method, expressed in terms of hydrogen ion concentration (C_H). The value of *k* at 25° C. found by us within the limits of acidity present in sour milk is 25×10^{-5} to 26×10^{-5}. We have not been able to confirm the value for *k* (14×10^{-5}) found by Ostwald[5] nor that ($k = 31 \times 10^{-5}$) published by Goldschmidt and Burkle.[6] Van Slyke and Van Slyke[7] found the value considerably higher than that of Ostwald.

EXPERIMENTAL.

It now remains to give some additional details as to how the work was performed in measuring the hydrogen ion concentration (C_H) value and the total amount of lactic acid formed in sour milk.

Fresh milk is run thru a centrifugal separator to remove fat and is pasteurized by holding 1 hour at 62° C. A portion is inoculated with a pure, uncurdled culture of *Bacterium lactis acidi* (1:10,000).[8] The inoculated milk is kept at 25° C. By actual testing it was found that the culture remained pure thruout the duration of each

[3] Clark, W. M., *J. Biol. Chem.*, 23:480, 1915.
[4] Cullen, G. E., *J. Biol. Chem.*, 30:371, 1917.
[5] Ostwald, W., *Z. physik. Chem.*, 3:193, 1889.
[6] Goldschmidt, H., and Bürkle, E. *Ber. chem. Ges.*, 32:364, 1899.
[7] Van Slyke, L. L., and Van Slyke, D. D. N. Y. Agrl Expt. Sta. Tech. Bul., 3, 1906, and *Am. Chem. J.*, 38:400, 1907.
[8] This and the other cultures referred to later were furnished by Mr. G. L. A. Ruehle, Assistant Bacteriologist at this Station.

experiment. Before inoculation and at intervals after, portions are removed with a sterile pipette and the C_H values immediately determined; this requires about 15 minutes. The results are stated in values of pH and C_H. The temperature is kept at 25° C. during the whole operation.

In each case, the titration with alkali to determine the total amount of lactic acid that has been formed is made immediately before the E. M. F. reading. Thus both determinations are practically simultaneous and any possible error due to difference in time is inappreciable. The titration is made as follows: 0.1 N NaOH is added to 10 cc. of milk and 1 cc. of alcoholic solution of phenolphthalein until the first pink appears and remains about 60 seconds. The milk is measured with a rapid-delivery pipette calibrated to contain 10 cc. The milk adhering to the inner wall of the pipette is rinsed out with 10 cc. of distilled water, the rinsings being added to the sample to be titrated. With curdled milk the same procedure is followed, except that the 1 cc. of alcoholic solution of phenolphthalein is not added to the milk until sufficient 0.1 N alkali has been added to dissolve most of the curd. This modification is made for the purpose of preventing the hardening effect of the alcohol upon the particles of casein, since such hardening makes it difficult to reach a sharp end-point reaction. With this modification, duplicate determinations in case of curdled milk can be obtained with an agreement within 0.05 cc.

The results of the work are embodied in Table I. In Column 1 the figures indicate the intervals of time between inoculation and sampling for determination. The results in Column 2 are obtained by direct titration in the manner already described, while the figures in Column 3 are found by subtracting the titration result of the fresh milk (18 cc.) from that found in the sample taken at each indicated interval of time. The values in Column 4 are obtained by direct determination, as already explained. The figures in Column 5 are the C_H equivalents of the pH values given in the preceding column and are used in calculating the results given in Column 6. The figures in Column 6 are obtained by use of the equation $x = \frac{ab}{a + k_t}$ in which all values are to be expressed in mols (the molecular weight in gm.) and k_t is taken as 25×10^{-5}. The values for a are based upon the figures in Column 3, while the values of b are given directly in Column 5. The figures in Column 7 are placed here as a matter of convenience for future reference.

The data embodied in Table I can be summarized in the following statements:

1. The total acid formed in the milk in the process of souring, as determined by titration and expressed as cc. of 0.1 N alkali

required to neutralize to phenolphthalein 100 cc. of milk, varies from 1 cc. at 15 hours after inoculation to 97.3 cc. 48 hours after inoculation.

2. The pH value of souring milk at different intervals runs from 6.50 (equivalent to C_H, 0.032×10^{-5}) in fresh pasteurized milk to 4.17 (equivalent to C_H, 6.8×10^{-5}) in the milk 48 hours after inoculation.

TABLE I.—RESULTS OF DETERMINATION OF FREE LACTIC ACID IN SOUR MILK BY MEASUREMENT OF C_H AND APPLICATION OF MASS LAW.

Time of sampling after inoc-ulation.	Total acidity 0.1 N NaOH required to neutralize 100 cc. of milk.	Increase of acidity due to lactic acid.	Hydrogen Ion Concentration Expressed as		0.1 N free lactic acid in 100 cc. of milk.	0.1 N lactic acid by partial ether ex-traction.
			pH	C_H		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Hrs.	*Cc.*	*Cc.*			*Cc.*	*Cc.*
0	18	—	6.50	0.032×10^{-5}	—	—
15	19	1.0	6.43	0.037 "	—	—
16	20.2	2.2	6.40	0.040 "	—	—
17	21.5	3.5	6.31	0.049 "	0.007	—
18	23.3	5.3	6.21	0.062 "	0.01	—
19	27.2	9.2	5.91	0.123 "	0.05	—
20	33.0	15.0	5.75	0.180 "	0.10	—
20½	36.8	18.8	5.58	0.265 "	0.20	—
21	41.7	23.7	5.46	0.35 "	0.33	—
21½	48.2	30.2	5.33	0.47 "	0.56	—
22	54.2	36.2	5.18	0.66 "	0.90	—
22½	63.6	45.6	4.98	1.05 "	1.84	2.0
23	73.8	55.8	4.73	1.90 "	3.95	3.7
23½	78.2	60.2	4.73	1.90 "	4.25	4.2
24	82.0	64.0	4.57	2.70 "	6.24	6.0
24½	82.3	64.3	4.56	2.80 "	6.50	6.3
29	101.5	83.5	4.32	4.80 "	13.40	14.0
48	115.3	97.3	4.17	6.80 "	20.80	22.0

3. The amount of 0.1N free lactic acid in 100 cc. of milk, calculated on the basis of the measurement of C_H and titration values and the application of the mass law, varies from 0.01 cc. at 18 hours to 20.8 cc. 48 hours after inoculation.

4. Comparing the results given in Column 3 with those in Column 6, we observe a wide difference between the total amount of acid formed in the milk during souring and the amount of lactic acid existing free. During the first 20 hours, the amount of free lactic acid present is very small, since that which forms combines at once

with the basic constituents of the milk. At 20½ hours after inoculation, under the conditions of our experiments, about 1 per cent of the total acid in the milk, shown by titration, exists as free lactic acid. This percentage increases to 4 per ct. of the total in 22½ hours, 7 per ct. in 23½ hours, nearly 10 per ct. in 24 hours, 16 per ct. in 29½ hours, and 22 per ct. in 48 hours.

2. PARTIAL EXTRACTION BY ETHER AND APPLICATION OF THE COEFFICIENT OF DISTRIBUTION.

Lactic acid, when dissolved in water, can be extracted in part by ether. When a water solution of lactic acid is treated with ether and the mixture shaken until the ether dissolves all of the acid that it can, the concentration of acid (a) in the ether layer, divided by the concentration of acid (b) remaining in the water layer, gives a resulting factor (k), which is constant at any one temperature for any solution of lactic acid, without regard to the relative volumes of the ether and water. In mixtures containing only lactic acid and water, this constant is approximately 0.08. These relations are expressed by the equation, $\frac{a}{b} = k$.

When, however, other substances are also present in solution, they may change the ratio. Therefore, in order to make use of this method in determining the amount of free lactic acid in sour milk, it is necessary to ascertain the effect of the compounds dissolved in milk upon the value of k. It is impossible to do this directly because of the neutralization of lactic acid by the calcium caseinate and basic phosphates and citrates in souring milk. For experimental work, a solution was prepared, consisting of a mixture of free lactic acid with chlorides of calcium, sodium, potassium, and magnesium in concentrations approximating, for the bases, the amounts present in average normal milk. In such a solution the value of k becomes 0.09 approximately. This figure, however, fails to take into consideration the effect of phosphates, citrates, or milk proteins on the value of k. The effect of casein could not be measured, but free phosphoric acid and citric acid were added to the mixture of lactic acid and chlorides, and the resulting mixture was partially extracted with ether. Under these conditions, the value of k becomes 0.095. The results of these experiments indicate that neither the salts nor acids used have a marked effect upon the coefficient of distribution of lactic acid between water and ether. Therefore, while this value of k (0.095) may not be regarded as being the strictly true value, it is sufficiently accurate to make this method of value in approximately measuring the amount of free lactic acid existing in sour milk, especially when taken in connection with the other methods used by us.

EXPERIMENTAL.

In applying this method, one puts 50 cc. of the milk under examination in each of two 100 cc. centrifuge tubes and adds to each about 50 cc. of acid-free ether. The tubes are closed with stoppers, leaving an air-space above the ether. The mixture is gently shaken at intervals, care being taken to avoid such vigorous shaking as would emulsify the mixture to such an extent as to prevent the ether later from being separated more than one-half by centrifuging. It requires about 15 minutes to complete the operation and bring the two layers into equilibrium. The mixture is then centrifuged until 25 cc. or more of the ether in solution separates as a clear layer so completely that it can be withdrawn. The clear ether from both tubes is then mixed, being poured off into a graduated cylinder, care being taken that only clear ether, unmixed with water or emulsion, be poured out. The total volume of ether is read and the ether is then transferred to the vessel in which titration is to be made. Water (about 25 cc.) is added and the ether evaporated, care being taken that the water solution does not boil or evaporate. The solution is then cooled and titrated with 0.05 or 0.02 N NaOH, free from carbonate, or with 0.02 N $Ba(OH)_2$, using phenolphthalein as indicator. The amount of free lactic acid present in the milk is calculated from the following equation (derived from the equation given above, $\frac{a}{b} = 0.095$):

$\frac{\text{cc. of 0.1 N alkali used}}{\text{cc. of ether decanted}} \times 1{,}050 =$ cc. of 0.1 N NaOH required to neutralize the lactic acid in 100 cc. of milk.

The figures in Table II give the results of determinations made by this method in the case of pasteurized milk inoculated with *Bacterium lactis acidi.*

The results were checked by measurement of C_H and application of the mass-law method previously described and were found to be in good agreement. In Table I results are given in the last column, showing the figures obtained by the two methods. The ether-extraction method gives reliable results, however, only when there is no ether-soluble acid present other than lactic acid. Such a condition exists when the only organisms present are *Bacterium lactis acidi* and *Bacillus bulgaricus;* but in milk soured in the ordinary way there may be at times some acetic acid.[9] This is illustrated by an experiment in which milk was inoculated with an ordinary "starter" and determinations of acid were made by ether extraction with the following results.

[9] Bosworth, A. W., and Prucha, M. J., N. Y. Agri. Expt. Sta. Tech. Bul. 14, 1910.

TABLE II. — RESULTS OF DETERMINATION OF FREE LACTIC ACID IN MILK BY EXTRACTION WITH ETHER AND USE OF COEFFICIENT OF DISTRIBUTION.

Time examined after inoculation.	0.1 N NaOH required to neutralize 100 cc. of milk.	Ether extract.	0.02 N NaOH required to neutralize free lactic acid in ether extract.	0.1 N NaOH required to neutralize free lactic acid in 100 cc. of milk.
Hrs.	*Cc.*	*Cc.*	*Cc.*	*Cc.*
Fresh.	17.0	—	—	—
20	51.2	60	0.8	2.8
21	64.0	44	1.0	4.8
22	70.0	54	2.5	9.7
48	98.0	58	6.4	23.2
96	99.0	52	5.9	23.8

By comparing the results in the last column of Table III with those in the last column of Table II, it is seen that after 23 hours, the figures in Table III are much in excess of those in Table II. This was found to be due to the presence of a volatile acid, probably

TABLE III.— RESULTS OF ETHER EXTRACTION METHOD IN ORDINARY SOUR MILK.

Time examined after inoculation.	0.1 N NaOH required to neutralize 100 cc. of milk.	Ether extract.	0.02 N NaOH required to neutralize free acid in ether extract.	0.1 N NaOH required to neutralize free acid in 100 cc. of milk.
Hrs.	*Cc.*	*Cc.*	*Cc.*	*Cc.*
22	50	55	0.6	2.3
23	61	52	1.0	4.0
28	80	48	4.4	19.3
48	90	53	10.2	40.4
96	95	60	12.5	43 7

acetic. The figures obtained after 23 hours in Table III fail, moreover, to agree satisfactorily with results obtained by calculations based on measurement of C_H and application of the mass-law equation.

3. DOUBLE ELECTROMETRIC TITRATION WITH LACTIC AND HYDROCHLORIC ACIDS.

In order to test the accuracy of the results obtained by the methods already described in determining the amount of free lactic acid in sour milk, it appeared desirable to make use of the method of electrometric titration described on page 14 applied to the same milk used in previous experiments, employing lactic and hydrochloric acids.

The use of the double electrometric titration of milk with lactic acid and hydrochloric acid in ascertaining the amount of free lactic acid is based upon the following considerations: If, working within the limits of the acidity of sour milk, we run each of these acids from burettes into separate portions of a milk until the same C_H of each is reached, we find on examining the burette readings that a larger amount of lactic acid has been used than of hydrochloric. This difference represents difference in ionization in the two acids. Since lactic acid is ionized only in small part, while hydrochloric acid is practically all ionized, it requires larger amounts of lactic acid to produce the same C_H; or, stated in another way, since the lactic acid is mostly un-ionized and relatively none of the hydrochloric acid is un-ionized, the difference between the amounts of lactic acid and hydrochloric acid required to produce the same C_H represents the amount of free lactic acid in the milk at the particular point of C_H. At the same C_H, the amount of base neutralized is the same for different acids and therefore the lactate and chloride in solution formed in milk on addition of the two acids are the same at the same C_H. It is believed also that no adsorption of these salts occurs to interfere with the accuracy of the determinations.

EXPERIMENTAL.

The electrometric titrations are made with N acid and 250 cc. of milk. The amounts of acid used (expressed as cc. of 0.1 N per 100 cc. of milk) are given in Column 1 of Table IV, the purpose being to imitate the souring of milk by successive small additions of acid. After each addition of acid, the C_H is measured, care being taken to follow the instructions already given in the preceding article. The pH values obtained for the different amounts of lactic acid and hydrochloric acid taken are used in preparing the chart shown in Fig. 3, which is based on the values given in Table IV. By interpolation, the results of titration can be found at equal pH values. Therefore, by inspection of this chart, we can ascertain the amount of free lactic acid at any pH point by the horizontal distances between the lactic acid and hydrochloric acid curves. It is noticeable that the curves for both acids coincide until we have added more than 24 cc. of 0.1 N acid per 100 cc. of milk, after which there is a divergence in values and this increases gradually.

The irregularity or flattening in the curves is noticeable when between 50 and 60 cc. of 0.1 N acid have been added. This is due to interference as a result of the coagulation of the casein by acid.

In Table IV, we give in the last three columns the results obtained by the three different methods we have been discussing for the determination of free lactic acid in sour milk; *viz.*, (1) by application of mass-law calculations to results of measurement of C_H, (2) by

double electrometric titration, and (3) by partial ether extraction and calculation by application of coefficient of distribution.

The agreement of the results obtained by these three methods is reasonably close until the coagulation point of casein is reached, after which it is not possible to secure uniformity in the distribution of acid in the curdled milk; this results in slightly lower values by the method of double electrometric titration. The action of the acid added to curdled milk is limited largely to the outer surface of

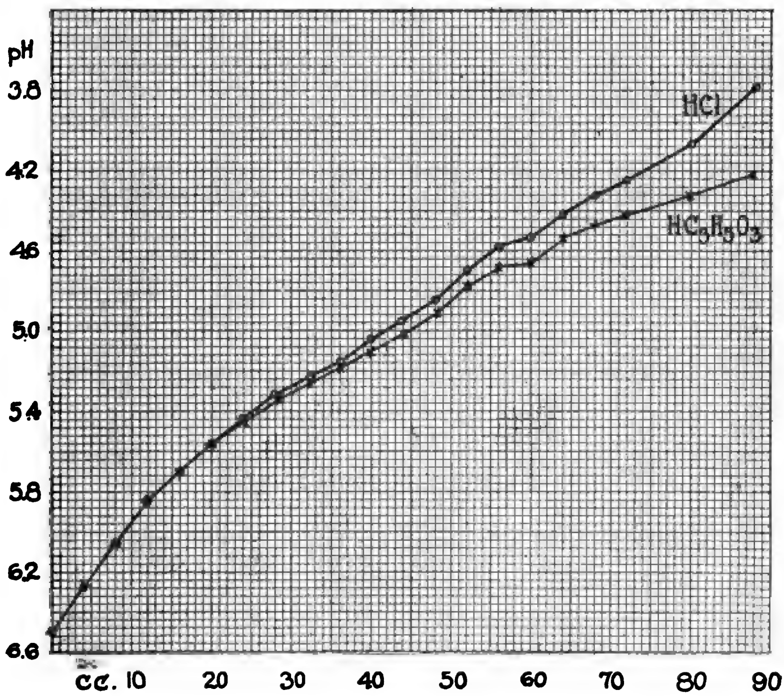

FIG. 3. This chart based on data in Table IV, enables one to find the amount of free lactic acid (0.1 N acid per 100 cc. of milk) at any point of hydrogen ion concentration expressed in terms of pH. This is done by measuring the horizontal distances apart shown by the lactic acid and hydrochloric acid curves at any one pH value.

the casein particles. Any di-calcium phosphate or calcium caseinate occluded in the coagulated casein particles is reached only slowly and incompletely by the process of diffusion. When milk sours naturally, each particle of curd or coagulated casein contains distributed through it millions of bacteria, which are producing acid; and the acid thus formed reaches the occluded basic salts more effectively, thus producing a reaction more nearly approaching equilibrium.

ADSORPTION OF LACTIC ACID BY CASEIN IN SOUR MILK.

Casein adsorbs lactic acid.[11] If free lactic acid is adsorbed by casein in sour milk, it is removed from the liquid phase and is, therefore, not determined by any of the methods previously described in this article. It seemed necessary, on this account, to ascertain how much lactic acid is adsorbed by casein under the conditions existing in sour milk and then make such correction as might be found to be needed, in order to learn the total amount of free lactic acid present in sour milk. Such a correction is based upon the assumption that adsorbed acid is removed as such in the molecular condition, an assumption justified by results to be presented later.

TABLE IV.—RESULTS OF DETERMINATION OF FREE LACTIC ACID BY METHOD OF DOUBLE ELECTROMETRIC TITRATION.

0.1 N Acid Used for 100 cc. of Milk.	Hydrogen Ion Concentration of Lactic Acid Added to Milk Expressed as		Hydrogen Ion Concentration of HCl Added to Milk Expressed as		0.1 N Free Lactic Acid in Sour Milk as Determined by Method of		
	pH	C_H	pH	C_H	Mass-law calculation.	Double electrometric titration.	Ether extraction.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cc.					*Cc.*	*Cc.*	*Cc.*
0	6.50	0.032×10^{-5}	6.50	0.032×10^{-5}			
4	6.28	0.053 “	6.28	0.053 “			
8	6.05	0.090 “	6.05	0.090 “			
12	5.84	0.146 “	5.85	0.143 “			
16	5.71	0.196 “	5.71	0.196 “			
20	5.56	0.280 “	5.56	0.280 “			
24	5.45	0.36 “	5.44	0.367 “			
28	5.35	0.45 “	5.32	0.48 “			
32	5.26	0.55 “	5.24	0.58 “	0.7	1.0	—
36	5.19	0.65 “	5.15	0.71 “	0.9	1.3	—
40	5.10	0.80 “	5.05	0.90 “	1.2	1.8	—
44	5.02	0.96 “	4.97	1.08 “	1.7	2.4	2.3
48	4.91	1.23 “	4.84	1.46 “	2.3	2.7	2.9
52	4.78	1.67 “	4.71	1.96 “	3.2	3.0	3.0
56	4.68	2.10 “	4.59	2.58 “	4.3	4.0	3.8
60	4.65	2.26 “	4.53	2.98 “	4.9	6.8	5.0
64	4.54	2.91 “	4.42	3.84 “	6.6	5.0*	7.0
68	4.47	3.43 “	4.32	4.80 “	8.1	6.0*	8.0
72	4.42	3.84 “	4.20	6.32 “	9.6	8.0*	10.0
80	4.32	4.80 “	3.97	10.80 “	13.0	12.0*	13.0
88	4.21	6.19 “	3.78	16.70 “	17.5	16.0*	19.0

* Results lower on account of coagulation of casein in milk by acid.

[11] Van Slyke and Van Slyke, N. Y. Agrl. Expt. Sta. Tech. Bul. 3, 1906, and *Am. Chem. J.*, 38:383, 1907.

For a discussion of the characteristics of adsorption phenomena, the reader is referred to the above cited article of Van Slyke and Van Slyke.

The amount of lactic acid adsorbed by casein in sour milk has been determined by us by four different methods, as follows:

(1) By adding definite amounts of casein to solutions containing given amounts of lactic acid and then determining the extent of reduction of the hydrogen ion concentration. (2) By the determination of the acidity of the filtrate after removal of casein under the same conditions as in the preceding method. (3) By the determination of the amount of acid retained by casein when separated from the whey in sour milk. The entire sour milk is titrated and also the separated whey, and the difference noted, correction being made for the known acidity of the casein. (4) By extraction of the lactic acid from sour milk and also from the separated whey, the difference between the two results being the amount of acid adsorbed.

1. ADSORPTION MEASURED BY REDUCTION OF HYDROGEN ION CONCENTRATION.

In the first two methods mentioned, the work is carried out with prepared solutions of lactic acid and calcium lactate, of known concentrations, to which given amounts of casein are added. These solutions are made of such concentrations as are known to exist in average sour milk; that is, 3 per ct. of casein and 0.065 normal of calcium lactate[12] and amounts of lactic acid varying according to the degree of acidity desired. Lactic acid solution of approximately normal concentration was boiled in a reflux condenser 48 hours in order to remove anhydride and this acid was used in preparing the solutions of known concentrations.

(1) Preparation of solution.— Proceeding now to give the details of the method used, we prepare the solutions containing lactic acid and calcium lactate in 100 cc. portions, the concentration being made twice that desired for the final concentration. This is divided into two portions of 50 cc. each, and the casein is added in the form

[12] The factor for calcium lactate, 0.065 normal, is obtained as follows: The free lactic acid in sour milk, as determined by application of the mass law (p. 29), or by the coefficient of distribution (p. 33), is subtracted from the total amount of acid in each case, as determined by titration, and the remainder, in case of milk soured by pure cultures of *Bacterium lactis acidi*, is assumed to be neutralized lactic acid, which is present in sour milk in combination chiefly as calcium lactate. Values for neutralized lactic acid (calcium lactate) obtained by this method, in case of several curdled milks, vary from 0.05 to 0.075, with an average of about 0.065 normal. Variations under the conditions found in sour milk in the amount of calcium lactate are not found to affect the proportion or percentage of the lactic acid that is adsorbed in case of equal hydrogen ion concentrations. While some lactate ion may be derived from the ionized lactic acid in a mixture of free lactic acid and calcium lactate, the amount is so small as to be negligible in comparison with that from the added calcium lactate.

of a 6 per ct. suspension to one portion, after which the volume of each is brought to 100 cc.

(2) *Preparation of casein.*— The casein used in these adsorption experiments is prepared by the method described by us on pp. 6 and 11 with the single variation that the washing with alcohol and ether is omitted. The casein is made into a water suspension, containing about 7 per ct. of casein, by vigorous beating after the fifth washing with water. Prepared in this manner, the casein remains a long time in persistent suspension. A portion (10 cc.) of this suspension is titrated to phenolphthalein with an excess of 0.1 N NaOH and the solution is titrated back to the neutral point with 0.1 N HCl. The amount of casein in the mixture is calculated on the basis of taking 1 gm. of casein as equivalent to 9 cc. of 0.1 N NaOH. If the casein in the suspension is beaten into fine enough particles, the titration gives an end-point reading that is accurate to about 0.2 cc. in a total titration of about 7 cc. Using the result thus obtained, the suspension is diluted so that there will be 6 gm. of casein in 50 cc. of the suspension.

(3) *Preparation of mixture of casein and solution.*— In preparing mixtures, in which we wish to measure the amount of decrease of hydrogen ion concentration, when casein is added to a solution containing lactic acid and calcium lactate, we mix 50 cc. of the 6 per ct. casein suspension at 25° C. with 50 cc. of each of the acid solutions at 25° C.; the different amounts of acid used are stated in Table V. The amount of casein in the mixtures thus prepared is 3 per ct., accurate within 0.1 per ct.

(4) *Determination of hydrogen ion concentration.*— After the mixture of casein and acid is completed, the C_H determination can be made at any time after 30 minutes, because the adsorption is complete within 30 minutes at 25° C. The E. M. F. of the solution without casein is first determined in duplicate after standing 24 hours. If the duplicates agree, the E. M. F. of the solution of the same concentration containing casein is determined, using the same electrode. (It is desirable to use freshly platinized electrodes for each set of two determinations.)

(5) *Calculation of results.*— From the procedure described, we obtain the following data: (*a*) The amount of lactic acid and calcium lactate used and the hydrogen ion concentration (C_H); (*b*) the C_H of lactic acid after the addition of casein, and from this latter figure we can obtain (*c*) the amount of lactic acid in the solution after the addition of casein. We can calculate the percentage of acid in the original solution that is adsorbed by the casein by using the amount of acid in solution, as obtained by calculation based on the hydrogen ion normal. We subtract the figure representing the acid in solution after addition of casein from the figure representing

the acid in the solution before addition of casein, and divide the result by the latter figure; or expressed as an equation, we have $\frac{a-b}{a}$ = per ct. of acid adsorbed; in which a is the amount of lactic acid used and b is the lactic acid in solution after adding casein.

The results of our work are given in Table V. In Column 1 is given the amount of lactic acid used and in Column 2 the amount of acid present after the addition of casein, as determined by the method of calculation described above. In Columns 3 and 4 are given the pH values of the lactic acid present before and after adding casein, as found by actual measurement, while in Columns 5 and 6 are given the hydrogen ion normal values corresponding to the pH values given in Columns 3 and 4. In Column 7 are given the percentages of the used lactic acid that is adsorbed by casein, which is present in suspension to the extent of 3 per cent. The values in Column 7 are obtained by the method of calculation already described.

By comparing the figures in Table V, Column 3, with those in Table III, Column 4, it is seen that the range of real acidity within which we have studied the question of adsorption is considerably wider than that found in sour milk.

TABLE V.— ADSORPTION OF LACTIC ACID BY CASEIN, BASED ON C_H VALUES.

0.1 N LACTIC ACID IN 100 CC. OF SOLUTION.		LACTIC ACID IN SOLUTION, EXPRESSED AS pH.		LACTIC ACID IN SOLUTION, EXPRESSED AS C_H.		Proportion of free lactic acid in milk adsorbed by casein.
Without casein.	With casein.	Without casein.	With casein.	Without casein	With casein	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cc.	Cc.					Per ct.
5	5.3	4.67	4.65	0.21×10^{-4}	0.22×10^{-4}	0
5.5	5.7	4.65	4.64	0.22 "	0.23 "	0
6	6.2	4.62	4.60	0.24 "	0.25 "	0
6.5	6.5	4.58	4.59	0.26 "	0.26 "	0
7	7.0	4.57	4.57	0.27 "	0.27 "	0
8	7.5	4.51	4.55	0.31 "	0.29 "	6
9	8.2	4.44	4.48	0.36 "	0.33 "	9
20	15.4	4.12	4.23	0.76 "	0.59 "	22
30	22.0	3.89	4.02	1.30 "	0.96 "	27
40	28.0	3.77	3.93	1.70 "	1.20 "	30

In studying the results in Table V, those in Column 7 attract our special interest. According to these results, no lactic acid is adsorbed by casein under the conditions of our experiments until the casein

is added to a solution which has a pH value of 4.51. From that point on to higher degrees of acidity, adsorption increases with increase of lactic acid.

The percentages of lactic acid adsorbed at different concentrations of hydrogen ion have been plotted (Fig. 4). By means of this, one can approximately ascertain the percentage of acid adsorbed in any given sour milk, provided the hydrogen ion concentration of such milk is known.

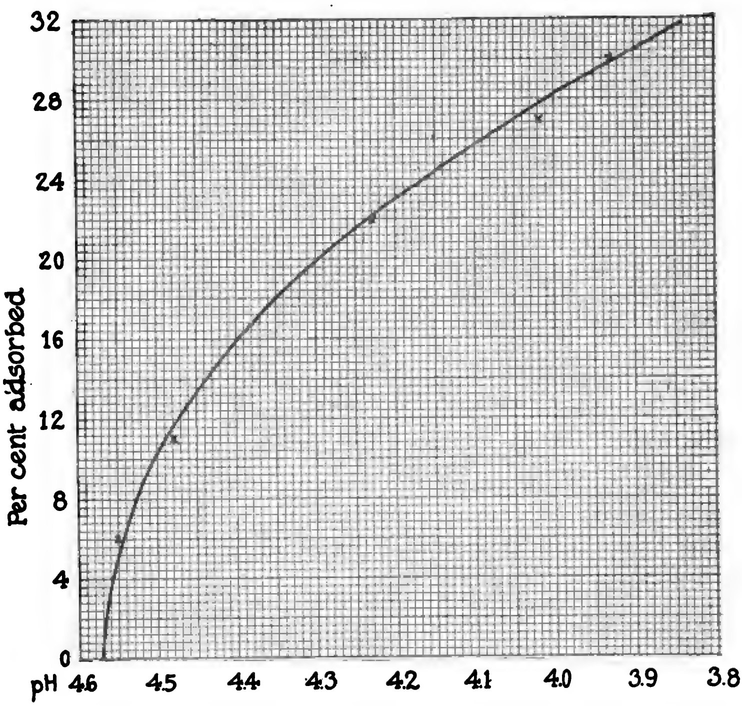

FIG. 4. This chart shows the approximate percentage of the free lactic acid in sour milk that is adsorbed by 3 per ct. of casein at different degrees of hydrogen ion concentration expressed in terms of pH.

There is an apparent disagreement between the results in Table V and those published by Van Slyke and Van Slyke,[13] who found under the conditions of their experiments that some lactic acid is always adsorbed even at low concentrations, while our results, on the contrary, show no adsorption when we use not more than 7 cc.

[13] Van Slyke and Van Slyke, N. Y. Agrl. Expt. Sta. Tech. Bul. 3, 1906 and *Am. Chem. J.*, 384:35, 1907.

of 0.1 N lactic acid per 100 cc. of solution. There is, however, no real disagreement when the difference of conditions in experiments is taken into consideration. In their work, lactic acid and casein only were used, while in our work there is present, in addition, calcium lactate, in order to imitate the conditions in sour milk. The presence of calcium lactate greatly reduces the ionization of the lactic acid, so that the amount of ionized lactic acid is less in our experiments, even tho the amount of free acid is greater. To such an extent is this true that in the solutions containing 7 cc., and less, of added 0.1 N acid per 100 cc. of solution, the hydrogen ion concentration is below the isoelectric point of casein, which equals C_H, 0.27×10^{-4}, a value in close agreement with that (0.24 to 0.26×10^{-4}) found by Michaelis.[14] By isoelectric point, we mean that hydrogen ion concentration at which the positive and negative charges on colloidal particles are equal. At this point casein is combined with neither base nor acid. When pure casein is added to a solution having the same reaction, it is found, as seen in Table V, Columns 1 and 2, that the $C_H^{\cdot}$ remains unchanged and, therefore, no acid is removed by casein through adsorption. When the C_H is below 0.27×10^{-4}, then casein and calcium lactate undergo reaction, calcium combining with casein to form calcium caseinate with simultaneous formation of free lactic acid. Under these conditions, it is not likely that casein could adsorb lactic acid at the same time that it is combining with calcium. At the isoelectric point casein combines with neither acid nor base. If adsorption occurred below C_H, 0.27×10^{-4}, the resulting solution would have a lower C_H, which is contrary to our results.

2. ADSORPTION MEASURED BY RESULTS OF TITRATION.

In obtaining the titration values for determining the percentage of acid adsorbed by casein, we prepare, as in the case of the preceding method, known solutions of lactic acid and calcium lactate and add to each of these enough casein in suspension to make the mixture contain 3 per ct. The mixture of acid solution and casein is shaken vigorously for a short time and then filtered, the first few cc. of filtrate being rejected. Then a portion of 10 cc. is titrated to phenolphthalein with 0.01 N NaOH. The amount of acid in the original solution, less the amount of acid shown by titration of the filtrate, divided by the amount of acid in the original solution gives the percentage of the acid used that is adsorbed by the casein.

However, the titration values need to have a correction applied in the form of a reduction of 0.6 cc. If we compare the amounts of lactic acid used with the amounts found after the addition of casein, we find that the amounts of acid, as determined by titration, are considerably higher after addition of casein than the amounts orig-

[14] Michaelis, L., and Pechstein, H., *Biochem. Z.*, 47:260. 1912.

inally used and also higher than the amounts found by measurement of the hydrogen ion concentration. This is obvious if we examine the first three columns in Table VI. Thus, we notice that when we add casein to a solution containing 7 cc. of 0.1 N lactic acid per 100 cc., the value obtained by the determination of C_H shows the same amount of acid, which means that no adsorption takes place at that point of acidity. But the titration value at the same point gives 7.6 cc. of 0.1 N lactic acid, or an excess of 0.6 cc. over the amount with which we started. This amount of excess deducted from the titration values in Column 3, Table VI, gives the results found in Column 4.

TABLE VI.—ADSORPTION OF LACTIC ACID BY CASEIN, BASED ON TITRATION RESULTS.

0.1 N Lactic Acid in 100 cc. of Solution.			Corrected titration values.	Lactic acid adsorbed by casein, based on titration.	Lactic acid adsorbed by casein, based on C_H determination.	Casein in solution in filtrate.
Without casein.	With casein by C_H method.	With casein by titration.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cc.	*Cc.*	*Cc.*	*Cc.*	*Cc.*	*Per ct.*	*Per ct.*
5.0	5.3	6.2	5.6	0	0	0.0145
5.5	5.7	6.6	6.0	0	0	0.0155
6.0	6.2	7.0	6.4	0	0	0.0160
6.5	6.5	7.2	6.6	0	0	0.0165
7.0	7.0	7.6	7.0	0	0	0.0170
8.0	7.5	8.2	7.6	5	6	0.0175
9.0	8.2	8.8	8.2	9	9	0.0185
20.0	15.4	16.9	16.3	19	23	0.0250
30.0	22.0	24.7	24.1	20	27	0.0400

The cause of the discrepancy which requires the correction in the titration results may be found to be due to one or both of two reactions which affect the titration: (1) There may be a reaction between the calcium lactate and casein, resulting in the formation of insoluble calcium caseinate and free lactic acid, which would increase the titration results. (2) There is dissolved casein present in the filtrate, which would increase the titration somewhat. The amounts of casein in the filtrate are given in Column 7 of Table VI. The determinations of casein were made by colorimetric methods with standard solutions of casein dissolved in nitric acid, the work of Van Slyke and Van Slyke[15] being used as a basis for the method, in connection with a Duboscq colorimeter.

[15] Van Slyke and Van Slyke, N. Y. Agrl. Expt. Sta. Tech. Bul. 3, 1906, and *Am. Chem. J.*, 38: 406, 1907.

The chief interest in the results in Table VI lies in Columns 5 and 6. We find that the percentage of lactic acid adsorbed by casein agrees closely by the two methods within the range of acidity commonly found in sour milk.

3. ADSORPTION MEASURED BY TITRATION ACIDITY IN SOUR MILK AND WHEY.

It is essential to know whether the results obtained in the preceding experiments are applicable to the conditions existing in sour milk. In order to ascertain this, special experiments have been made with sour milks. If we determine the acidity of whole or unseparated curdled milk and then of its separated whey, we find the acidity of the whey less than that of the whole sour milk. The difference is due to the free casein which is present in the whole curdled milk but absent from the whey. A part of this difference of acidity is due directly to the neutralizing or base-combining power of free casein, 1 gm. of casein requiring for neutralization to phenolphthalein 9 cc. of 0.1 N alkali. The other and smaller portion of decrease of acidity is due to adsorption of acid by casein. For example, 100 cc. of a whole, curdled milk requires 100 cc. of 0.1 N NaOH to neutralize it to phenolphthalein. When the casein is removed and the whey neutralized, it is found to require only 72 cc., a difference of 28 cc. of 0.1 N alkali. This milk contains 2.8 per ct. of casein, which requires 25.2 cc. (9 cc. $\times$ 2.8) of 0.1 N alkali to neutralize it. Of the total 28 cc. decrease of acidity between the whole sour milk and the whey, 25.2 cc. are thus accounted for by the base-combining power of the casein, and this leaves 2.8 cc. to be accounted for as adsorbed by casein. On the basis of these statements, the amount of adsorption of acid by casein can be ascertained in the case of sour milk by subtracting from the total acidity of the milk the acidity of the whey and of the casein in the milk.

We have completed experiments with four different sour milks in the line indicated by the foregoing statements.

Milk, in which the percentage of casein is determined, is treated with a pure culture of *Bacterium lactis acidi* and allowed to stand at 25° C. until curdled. A portion of the curdled milk is titrated to phenolphthalein with 0.1 N NaOH by the method already described (p. 31) care being taken to dissolve the casein completely. Then a known amount of the curdled milk is whirled in a centrifugal test-tube until the whey separates in a clear, supernatant layer above the solid layer of casein. A given amount of the separated whey is titrated to phenolphthalein with 0.1 N NaOH. The results of these experiments are given in Tables VII and VIII. The results in the last column of Table VII are obtained by adding the figures in Columns 3 and 6 in each experiment and subtracting the sum from the figures in Column 5.

TABLE VII.— ADSORPTION OF LACTIC ACID BY CASEIN IN SOUR MILK. RESULTS BASED ON TITRATION.

No. of experiment.	Casein in milk.	Acidity of casein expressed as 0.1 N NaOH.	Milk analyzed after inoculation.	AMOUNT OF 0.1 N NaOH REQUIRED TO NEUTRALIZE		Amount of 0.1 N lactic acid adsorbed by casein for 100 cc. of sour millk.
				100 cc. of whole sour milk.	Whey from 100 cc. of sour milk.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Per ct.	*Cc.*	*Hrs.*	*Cc.*	*Cc.*	*Cc.*
1	2.70	24.3	48	106	78.0	3.7
2	2.80	25.2	48	99	70.8	3.0
3	2.79	25.1	72	100	72.2	2.7
4	2.87	25.8	96	107	78.0	3.2

The data in Table VII enable us to find the amount of lactic acid adsorbed by casein for 100 cc. of sour milk. In order to find what percentage of the free lactic acid present in sour milk is adsorbed, we must know also the amount of this free lactic acid, and this is obtained from the data in Table VIII by application of the mass-law calculation (p. 257 and Table III, p. 263).

TABLE VIII.— FREE LACTIC ACID IN SOUR MILK USED IN EXPERIMENTS.

No. of experiment.	Total acidity 0.1 N NaOH required to neutralize 100 cc. of sour milk.	Acidity of fresh milk 0.1 N required to neutralize 100 cc. of fresh milk.	Total lactic acid formed in milk. Total acidity less acidity in fresh milk.	Hydrogen ion concentration expressed as pH.	Equivalent of pH value expressed as C_H.	0.1 N free lactic acid in 100 cc. of sour milk.
	Cc.	*Cc.*	*Cc.*			*Cc.*
1	106	16.5	89.5	4.25	5.6×10^{-5}	16.4
2	99	18.0	81.0	4.27	5.4 "	14.4
3	100	18.0	82.0	4.37	4.3 "	12.0
4	107	19.0	88.0	4.33	4.7 "	14.0

From the figures in the last columns of Tables VII and VIII, we can calculate the percentage of free lactic acid adsorbed by the casein in 100 cc. of sour milk. We obtain the following values:

No. of experiment.	Free lactic acid in 100 cc. of sour milk.	Lactic acid adsorbed.	Percentage of lactic acid in sour milk adsorbed.
	Cc.	*Cc.*	
1	16.4	3.7	23
2	14.4	3.0	21
3	12.0	2.7	22
4	14.0	3.2	23

If we use the pH values in Table VIII in connection with the adsorption curve (p. 270), we obtain the following figures for the percentage of lactic acid adsorbed by casein in sour milk.

Experiment No.	Percentage by adsorption curve.	Percentage by titration.
1	22	23
2	21	21
3	18	22
4	18	23

It may be stated in connection with the method of measuring adsorption by means of titration values, as described above, that we appreciate that it is open to some serious objections. All errors in titrations fall upon the value obtained for adsorption and these may be considerable unless one is accustomed to the method and performs the work with care. The amount of adsorption is small and errors in work are therefore of relative prominence. Its value lies mainly in affording an independent or additional means of measuring adsorption in connection with other methods.

4. ADSORPTION MEASURED BY EXTRACTION OF LACTIC ACID IN SOUR MILK AND WHEY.

A measured portion of sour milk is extracted about 48 hours by hot ether in a continuous extractor, enough phosphoric acid being added to convert all lactates into free lactic acid. A given portion of whey, obtained in the manner already described (p. 273),

is extracted in the same way. We thus obtain the total lactic acid formed in the milk during the process of souring and also the total in the whey. The difference represents directly the amount adsorbed by the casein in the milk. This method is applicable in case of milk soured by such pure cultures as are known to produce only lactic acid. The method was applied to the milks numbered 1, 2, and 3 used in the preceding experiments.

TABLE IX.—ADSORPTION OF LACTIC ACID MEASURED BY EXTRACTION OF SOUR MILK AND WHEY.

No. of experiment.	Amount of 0.1 N lactic acid in 100 cc. of sour milk.	Amount of 0.1 N lactic acid in whey for 100 cc. of sour milk.	Amount of 0.1 lactic acid adsorbed by casein in 100 cc. of sour milk.	Amount of 0.1 N free lactic acid in 100 cc. of sour milk.	Percentage of lactic acid in sour milk adsorbed by casein.
	Cc.	*Cc.*	*Cc.*	*Cc.*	
1	90.1	85.8	4.3	16.4	26
2	81.2	77.7	3.5	14.4	24
3	84.0	81.5	2.5	12.0	21

A comparison of the results obtained by the four methods employed are in approximate agreement in showing that in sour milk about 20 to 25 per ct. of the entire free lactic acid present in the milk is adsorbed by casein. When we consider the total amount of lactic acid (free and combined as lactates) that is formed in sour milk, the percentage adsorbed amounts in most cases to only 2.5 to 3.5 per ct. approximately.

In accordance with our results, it is sufficiently accurate to make an allowance of about 20 per ct. of the free lactic acid in sour milk as the amount adsorbed by casein. Therefore, in estimating the total amount of free lactic acid in sour milk, we determine the amount of free lactic acid in solution by the method based on the C_H value (p. 257) and to this result add 20 per ct. of itself.

In this connection the question may be raised as to whether other acid constituents of milk, such as acid phosphate and citrate salts, are not also adsorbed by casein. Some special experiments were made to test this point. Solutions with hydrogen ion concentration approximately equal to that of sour milk were made, in all of which there was the same concentration of lactic acid but varying amounts of other constituents. Some contained only lactic acid and calcium lactate, while others contained also acid citrate or acid phosphate in the approximate portions present in milk. To each of these different solutions casein suspension was added to the

extent of 3 per ct. in the manner previously described (p. 268) and the reduction of hydrogen ion concentration was measured. In all cases the results showed no greater removal of acid by casein from those solutions containing acid citrate and phosphate than from the one containing only lactic acid. Similar experiments in which acetic acid was present gave only slightly increased adsorption of acid. The results with acid citrate and phosphate solutions are in harmony with the fact that all the citrate and phosphate in sour milk are found in the serum.[16]

ACIDITY OF SOUR MILKS.

In connection with the work already described, it is a matter of interest to know something more in relation to the amount of acid produced in milk when soured under different conditions. We therefore present additional data obtained from a study of sixteen samples of sour milk. In all cases the milk was kept at 25° C. during the process of souring. In samples 1 to 3, the souring was effected by *Bacterium lactis acidi* inoculated in pasteurized milk; in Sample 4, by *Streptococcus lacticus;* in Samples 5 and 6, by *Bacillus bulgaricus;* in Samples 7 to 12, by natural souring, that is, by using unpasteurized milk which was self-inoculated by lactic organisms getting into the milk during milking and subsequent handling; in Samples 13 to 15, by inoculating unpasteurized milk with a more or less impure lactic culture or so-called starter of sour milk. Sample 16 is the same as 15 but is diluted with one-half its volume of water, enough lactose being added to make the amount of lactose the same as in the undiluted milk.

The interval of time after inoculation before analysis varied from 1 to 10 days. The determinations made were (1) hydrogen ion concentration; (2) the amount of free lactic acid, including that adsorbed, obtained by methods previously described in this article; (3) the total amount of lactic acid present in the form of lactate, obtained by difference between total and free acid. The detailed results are given in Table X. The examination of the sour milks was made at the stage of souring at which increase of acidity is very slow. In no case have we found increase of acid and C_H ceasing entirely within the limits of time covered by our work.

(*1*) *Hydrogen ion concentration of sour milk.*— An examination of Table X indicates that there is no specific C_H value that is characteristic of sour milk. The results differ according to a variety of conditions, and especially with the kind of organism responsible for the souring and its rate of growth. In the case of milk that sours in the ordinary way (Samples 7 to 12), the pH value varies from

[16] Van Slyke and Bosworth, N. Y. Agrl. Expt. Sta. Tech. Bul., 30, 1914, and *J. Biol. Chem.*, 24:193, 1916.

4.43 to 4.02, and with milks soured by "starter" (Samples 13 to 15), the variations are within similar limits of pH value, 4.36 to 4.22. In the case of pure cultures of *Bacterium lactis acidi* (Samples 1 to 3), the variations (pH 4.34 to 4.03) are within the same limits as observed in case of natural souring. This would, of course, be expected, since in natural souring or in the use of a sour-milk "starter," the organism chiefly or wholly responsible for the acidity is usually *Bacterium lactis acidi*. In the case of *Streptococcus lacticus*, a minimum acidity is observed (pH 4.56).

TABLE X.— ACIDITY OF MILK SOURED UNDER DIFFERENT CONDITIONS.

No. of sample.	Days analyzed after inoculation.	Hydrogen Ion Concentration Expressed as		0.1 N free lactic acid in 100 cc. of milk.	0.1 N free lactic acid adsorbed by casein in 100 cc. of milk.	0.1 N total free lactic acid in 100 cc. of milk.	0.1 N lactic acid in form of lactate in 100 cc. of milk.	0.1 N total lactic acid formed in 100 cc. of sour milk.
		pH.	C_H					
				Cc.	*Cc.*	*Cc.*	*Cc.*	*Cc.*
1	2	4.17	6.8×10^{-5}	21.0	4.8	25.9	71.4	97.3
2	2	4.03	7.2 "	26.5	7.6	33.7	64.3	98.0
3	3	4.34	4.6 "	14.2	2.4	16.6	74.4	91.0
4	6	4.56	2.9 "	8.3	3.0	8.6	71.4	80.0
5	4	3.86	14.0 "	64.0	23.0	87.0	92.0	179.0
6	10	3.70	20.0 "	98.0	36.3	134.0	80.0	220.0
7	3⅓	4.14	7.2 "	21.0	5.0	26.0	67.5	93.5
8	2	4.02	9.5 "	27.2	7.3	34.5	64.5	99.0
9	2½	4.37	4.3 "	14.7	2.3	17.0	83.0	100.0
10	2¾	4.35	4.5 "	16.4	2.8	19.2	88.3	107.5
11	3	4.32	4.8 "	16.1	2.9	19.0	81.0	100.0
12	3	4.43	3.7 "	11.6	1.5	13.1	76.9	90.0
13	1	4.36	4.4 "	14.4	2.3	16.7	79.3	96.0
14	1	4.36	4.4 "	13.6	2.2	15.8	75.2	91.0
15	3	4.22	6.0 "	20.0	4.4	24.4	77.6	102.0
16	3	4.15	7.1 "	15.0	3.7	18.7	51.8	70.5

(*2*) *Total amount of acid formed.*— The total amount of acid formed in 100 cc. of sour milk is usually between 90 and 100 cc., expressed as 0.1 N acid, when the organism present is mainly *Bacterium lactis acidi*. In the case of *Bacillus bulgaricus*, the acidity may reach or exceed 200 cc. under the conditions of our work.

(*3*) *Free lactic acid.*— The amount of free lactic acid, which includes that adsorbed, varies from less than 10 cc. of 0.1 N acid

per 100 cc. of milk to 134. In the case of the usual lactic organisms, the variation lies between 13 and 34.5 cc. With *Bacillus bulgaricus* (Samples 5 and 6), the figures for adsorbed acid are not accurate owing to some solution of casein by the acid.

(*4*) *Relation of total acidity to free lactic acid in sour milks.*— If we compare the total amount of acid formed in sour milk with the amount of free lactic acid, we find that the percentage of total acid existing as free lactic acid varies widely. In the case of milk soured by a pure culture of *Bacterium lactis acidi* or by a sour-milk "starter" or by so-called natural souring, the percentage of total acid in the form of free lactic acid varies from 14.6 to 35, in the majority of cases being somewhere about 20.

(*5*) *Lactate in sour milk.*— The amount of lactic acid present as lactate in sour milk is much more uniform, of course, than the free acid, since the amount of lactate in the presence of an excess of free acid is primarily dependent on the amount of basic compounds in each milk, and these do not usually vary widely in amount. In the samples of milk used in our experiments, the amount of lactate, equivalent to 0.1 N lactic acid, varies from 64.3 to 92 cc. per 100 cc. of milk.

(*6*) *Effect of dilution of milk on acidity.*— The effect of dilution by water is shown in Samples 15 and 16. In Experiment 15, normal milk was used, and in No. 16 the same milk diluted so as to contain one-third of its final volume of added water, enough lactose being added to make the percentage the same as in Sample 15. The effect of the dilution is to increase the hydrogen ion concentration, owing to the fact that there is less base to neutralize in the diluted milk. The degree of acidity is relatively greater in the diluted milk, if we take the amount of dilution into consideration. For example, the total acidity in the undiluted milk is equal to 102 cc. of 0.1 N acid in 100 cc. of milk, while in the diluted milk, the acidity is 70.5 cc., whereas it would be one-third less or 68 cc. if it were exactly in proportion to dilution.

COAGULATION POINT OF CASEIN IN THE SOURING OF MILK.

Another point of interest in connection with milk soured at 25° C. is the relation of hydrogen ion concentration to the curdling of milk; that is, the coagulation of casein. In ten samples of milk soured in the ordinary way, the hydrogen ion concentration and total acidity as determined by corrected titration (p. 259) are given. The determinations were made as nearly as possible at the time when the milk began to show the first signs of thickening; but in only four samples (Nos. 5 to 8) were we able to catch the thickening at the exact beginning. In these four samples the same determinations were repeated when the coagulation became complete; that is,

when the milk formed a solid mass of curd. It is possible to catch the milk during this change only with considerable difficulty.

The data furnished by these experiments are given in Table XI.

TABLE XI.—RELATION OF HYDROGEN ION CONCENTRATION TO COAGULATION OF CASEIN.

No. of sample.	pH Value Coagulation.		C_H Value Coagulation.		0.1 N Acid in 100 cc. of Milk Coagulation.		Time between beginning and completion of coagulation.
	Beginning or under way.	Completed.	Beginning or under way.	Completed.	Beginning or under way.	Completed	
					Cc.	Cc.	Min.
1	4.64	—	2.3×10^{-5}	—	43	—	—
2	4.64	—	2.3 "	—	75	—	—
3	4.66	—	2.2 "	—	64	—	—
4	4.67	—	2.15 "	—	74.5	—	—
5	4.68	4.68	2.1 "	2.1×10^{-5}	56	58	40
6	4.68	4.68	2.1 "	2.1 "	71	74.5	60
7	4.70	4.70	2.0 "	2.0 "	73	78.2	30
8	4.73	4.73	1.9 "	1.9 "	73.8	78.2	—
9	4.75	—	1.8 "	—	69	—	—
10	4.78	—	1.7 "	—	58.9	—	—

Milk begins to coagulate during the process of souring when the pH value reaches 4.64 to 4.78, representing a change of C_H varying from 2.3×10^{-5} to 1.7×10^{-5}. The total acidity by titration varies from 43 to 75 cc. of 0.1 N acid per 100 cc. of milk.

The period of coagulation from beginning to completion varies from 30 to 60 minutes at 25° C. *The hydrogen ion concentration remains constant during the change.* The acidity by titration increases slightly, varying from 2 to 5.2 cc. of 0.1 N acid per 100 cc. of milk.

RELATION OF FIRST SIGN OF SOURING IN MILK TO HYDROGEN ION CONCENTRATION.

The first detectable sign of souring in milk is popularly thought to be a sour or acid taste or smell. As a matter of fact, that property which one associates with the first or preliminary stage of souring is more accurately characterized as a flavor; that is, a quality perceptible to the two senses of taste and smell. It is a common experience for one, when suspicious of the condition of milk or cream, to smell of it or taste of it and to say that it smells sour or tastes sour when it does not taste really acid. In the ordinary souring of milk, some volatile compound or compounds, not

possessing a sour or acid taste, are regularly formed in minute amounts as preliminary products or by-products of the process of lactic acid formation. Much remains to be learned about the details of the process. As a result of associating the odor and taste of such volatile flavor products with the acid or sour taste of milk, we have formed the habit of saying that milk tastes sour whenever we detect this associated flavor, even though there is no real sour or acid taste.

As a preliminary study, we have made some observations in the case of several samples of milk undergoing the process of souring, in which the milk was examined at intervals of 1 hour or less for the characteristic flavor or so-called sour taste preceding the appearance of actually sour or acid taste. When it was possible in the sample under observation to detect by the taste and smell the first indication of the characteristic flavor, we at once made determination of the hydrogen ion concentration and acidity by titration. The samples numbered 1 to 4 were soured in the ordinary way at 25° C. without addition of organisms; Samples 5 and 6 were pasteurized and then inoculated with a sour-milk "starter" which had been nearly neutralized with dilute alkali.

The results of the work are given in Table XII.

TABLE XII.— HYDROGEN ION CONCENTRATION IN RELATION TO FIRST STAGE OF SOURING IN MILK.

No. of sample.	Time after starting experiment when sample was examined.	0.1 N acid formed in 100 cc. of milk.	Hydrogen ion Concentration Expressed as	
			pH.	C_H.
	Hrs.	*Cc.*		
1	21	37.5	5.44	0.37×10^{-5}
2	34	24.2	5.44	0.37 "
3	28	31.5	5.49	0.33 "
4	24	26.5	5.49	0.33 "
5	20	18.8	5.58	0.26 "
6	21	22.0	5.60	0.25 "
7	6	15.0	5.96	0.11 "

The data in Table XII do not show any relation of the hydrogen ion concentration to the time at which the characteristic flavor indicative of the souring process is first discernible. In no case did the milk taste distinctly acid; and, if the nasal passages were closed, there was no taste at all. The so-called sour flavor could be perceived by the smell alone or by the combined sense of taste and

smell. Solutions containing lactic acid and calcium lactate have a much higher hydrogen ion concentration (about 5.1 pH or C_H, 0.8×10^{-5}) before they taste sour or acid than any in Table XII. Milk to which lactic acid is added fails to develop the flavor characteristic of milk naturally soured. The compound or compounds responsible for the flavor in question are due to bacterial action without doubt.

The results here presented are of value chiefly for their suggestiveness as a basis for further work.

REPORT

OF THE

Department of Entomology.

P. J. PARROTT, *Entomologist.*

HUGH GLASGOW, *Associate Entomologist.*

H. E. HODGKISS, *Assistant Entomologist.*

B. B. FULTON, *Assistant Entomologist.*

F. Z. HARTZELL, *Associate Entomologist.*
(Connected with Grape Culture Investigations.)

TABLE OF CONTENTS.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

LEAF-HOPPERS INJURIOUS TO APPLE TREES.*

F. H. LATHROP.

SUMMARY.

Observations of outbreaks of leaf-hoppers in nursery and orchard plantings during recent years show that apple trees in New York are especially subject to attack by three species, which are *Empoasca mali* Le Baron, *Empoasca unicolor* Gillette and *Empoa rosæ* Linnaeus.

As the insects are important pests and display great similarities in certain activities as well as in the resemblance of nymphal and adult stages, recognition characters for distinguishing the various forms are noted and the more marked differences in their habits and life histories are indicated.

Contrary to certain recorded observations, *E. mali* hibernated largely, if not exclusively, in the adult stage. Two generations were observed. The species *E. unicolor* spent the winter in the egg stage and was single brooded, while *E. rosæ* over-wintered in the egg stage, largely on roses, although a few eggs were placed on apples. This latter species had two generations.

The leaf-hoppers differ considerably in feeding habits. The species *E. mali* obtains its food almost exclusively on tender terminal growth, causing a characteristic curling of the foliage. Both *E. rosæ* and *E. unicolor* feed largely on older leaves and they may be found on young and old apple trees. The former is more abundant on older trees, while the latter is more numerous on younger trees. Leaves attacked by the two species display white stippling of the upper surfaces.

In experiments with the leaf-hoppers as carriers of fire blight (*Bacillus amylovorus* Burrill), positive results were obtained with *E. mali*. No infections were noted in similar efforts with

* Reprint of Bulletin No. 451, September, 1918.

associated species, and the role of these as potential carriers of the disease was not clearly indicated.

The leaf-hoppers have a number of natural enemies, as various small spiders and hymenopterous parasites. A common and destructive enemy of *E. rosæ* is the egg parasite, *Anagrus armatus* Ashmead.

For protection from leaf-hoppers, chief reliance should be placed on spraying with soap and nicotine mixtures to combat the younger nymphs. A supplementary measure is destruction of weeds which harbor the insects.

INTRODUCTION.

Among the serious insect pests of the apple there should be listed three species of small leaf-hoppers. The magnitude of the damage caused by one of these, *Empoasca mali* Le Baron, has long been recognized. In fact, this species has for years been popularly termed "the apple leaf-hopper." Recognition of the other two species (*Empoasca unicolor* Gillette and *Empoa rosæ* Linnaeus), which are considered in this paper as important apple pests, is more recent. Observations on the activities of these insects indicated that, in many instances, they have been confused, all three being termed "the apple leaf-hopper" by the casual observer and hence referred to as *Empoasca mali.* Failure to recognize the associated forms has probably led to errors in observations of the habits and life histories of the insects, and for this reason an investigation of the different species was considered very desirable.

SYSTEMATIC RELATIONSHIPS.

The species under consideration are closely allied, belonging to the family Cicadellidæ and the sub-family Typhlocybinæ. This sub-family is made up of small, fragile species, very much alike in general appearance, and in some instances so similar that they can be separated only by very careful and minute examination. Among the nearly related forms may be mentioned the grape leaf-hopper, *Erythroneura comes*, a well known pest of grapes; *Empoasca flavescens*, which is almost identical with *Empoasca mali;* and several other species of *Erythroneura* and *Empoasca* attacking various wild and cultivated plants.

The group is represented in North America by a number of genera which may be separated by the following table:

KEY TO THE NORTH AMERICAN GENERA OF TYPHLOCYBINÆ [1]

A. Sectors of hind wing ending in a marginal vein.
 B. Elytra with an appendix. *Alebra* Fieber.
 BB. Elytra without an appendix.
  C. Two apical cells in hind wing. *Dikraneura* Hardy.
  CC. One apical cell in hind wing. *Empoasca* Walsh.
AA. Sectors of hind wing ending in wing margin, no marginal vein.
 B. All four sectors of hind wing extending to margin. *Typhlocyba* Germ.
 BB. Sectors 1 and 2 of the hind wing uniting so that only three veins extend to the margin.
  C. Fore wing with the outer and middle sectors of the corium joined by a cross vein anterior to the apical cell, but not coalescing beyond the discal cell. *Erythroneura* Fitch.
  CC. Fore wing with the outer and middle sectors of the corium coalescing for a portion of the distance beyond the discal cell. *Empoa* Fitch.

BIOLOGY OF LEAF-HOPPERS.

DISTINGUISHING CHARACTERISTICS OF SPECIES ON APPLE.

The nymphs of *Empoa rosæ* may be distinguished from the other two species by the contour of the anterior margin of the vertex. The typical form may be readily determined by its white or whitish color, and even the deeper colored nymphs of *Empoa rosæ* do not usually approach the bright green of the other two species.

The nymphs of *Empoasca unicolor* and *E. mali* are green, and by this characteristic they may be separated from the preceding form with little difficulty. The nymphs of these two species, however, are very similar and are readily confused. The nymph of *E. uni-*

[1] Modified after key of Gillette, Proc. U. S. National Museum, XX, 710, 1898.

color differs most distinctly from that of *E. mali* in the contour of the anterior margin of the vertex, and there is also a difference in the coloration of the two nymphs. See Fig. 1.

Like the nymphs, the adult of *E. rosæ* is recognized by its white or whitish color. The adult of *E. unicolor* is a trifle larger and more

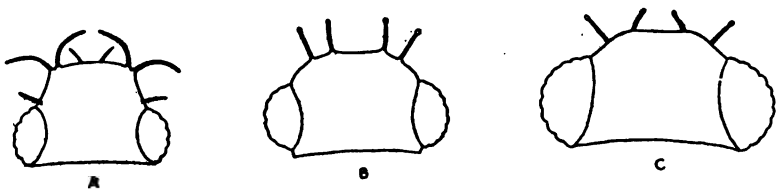

FIG. 1.—HEADS OF FIRST INSTARS SHOWING COMPARATIVE STRUCTURES AND SIZES.
A. Empoa rosæ. B. Empoasca mali. C. Empoasca unicolor.

robust than that of *E. mali;* however, the most reliable distinctive characteristics are the contour of the anterior margin of the vertex and the form of the female genitalia.

SEASONAL ACTIVITIES.

During the summer and fall of 1915 the district of western New York about Geneva experienced a heavy infestation of the apple leaf-hopper, *E. mali.* The foliage of apples in nursery plantings and of young orchard trees was severely curled. Similar injury was commonly observed on ornamental nursery stock of various kinds and the writer's attention was especially attracted by the injury to Norway maple and cut-leaf birch. During this season infestation by *E. rosae* was also quite common, and attacks of this species were in evidence in all orchards observed. The species *E. unicolor,* on the other hand, seemed to be comparatively rare, and no cases of severe infestation were observed.

The season of 1916 was fully two weeks later than normal, and there was a consequent delay in the beginning of insect activities. During the spring and summer of this season conditions were somewhat reversed with respect to numbers of leaf-hoppers. The species *E. mali,* though decidedly injurious, was much less in evidence than during the preceding season; while *E. unicolor* was exceedingly plentiful, proving to be a true pest, and by far outnumbering *E. mali.* *E. rosæ* was again prevalent, and, in spite of its natural enemies, did considerable injury.

LIFE HISTORY STUDIES.

Empoa rosæ.— This species spends the winter in the egg stage. By far the larger number of the winter eggs are deposited in the bark of the rose, although a few occur on apple.

On May 20 nymphs were found emerging from eggs on rose. The young nymphs immediately migrated to the undersides of the leaves and began feeding. The hatching of most of the eggs occurred almost simultaneously, and within a few days all of the nymphs had apparently emerged. The nymphs were common on roses, and many cases of very heavy infestation were observed. The apple, on the contrary, was almost entirely free of infestation, and only occasional nymphs of this generation could be found on this plant.

The first adults of the season appeared during the second week in June, and from that time on the numbers of adults increased, until by the latter part of the month practically all the nymphs had transformed. The adults migrated to apple, and after this the rose was almost deserted. After the middle of July the adults began to decrease noticeably and by the latter part of the month had become comparatively rare.

After the migration the eggs were deposited on apple. Nymphs of the second generation appeared during the middle of July, and during early August the adults of this generation occurred in numbers. The nymphs of the second generation reached their greatest abundance during the last week of July and the first week in August. From this time on the nymphs became less numerous, and by early October had become rare, although at this time the adults were numerous on apple.

Migration now took place from the apple to the rose, where most of the winter eggs were deposited. See Fig. 2.

Empoasca mali.— Forbes[2] noted this species as hibernating as adults; Gillette[3] also recorded the hibernation of adults, while Webster[4] reported hibernation as both adults and eggs.

The observations made at Geneva during this study show that this species hibernated largely, if not exclusively, in the adult form. During the winter three dozen one and two-year-old apple stock

[2] Forbes, S. A., Ent. Amer., II: 174, 1886.
[3] Gillette, C. P., Trans. Ia. State Hort. Soc., XXV: 104, 1890.
[4] Webster, R. L., Ia. Agrl. Exp. Sta., Bul. 111, 1910.

were planted in the green house. Numbers of leaf-hopper nymphs soon emerged from eggs deposited in the bark. The appearance of the nymphs was such that they might easily have been mistaken for *E. mali*, but when the adults developed they proved, without exception, to be *E. unicolor*. No nymphs of the former species appeared.

In the orchards, nymphs of *E. mali* appeared in numbers during the last ten days of June. This is obviously too early for the appearance of nymphs of the second generation, and is much too late for the hatching of the first generation had hibernation taken place in the egg stage. Adults were observed to be present at the time of the first appearance of the nymphs.

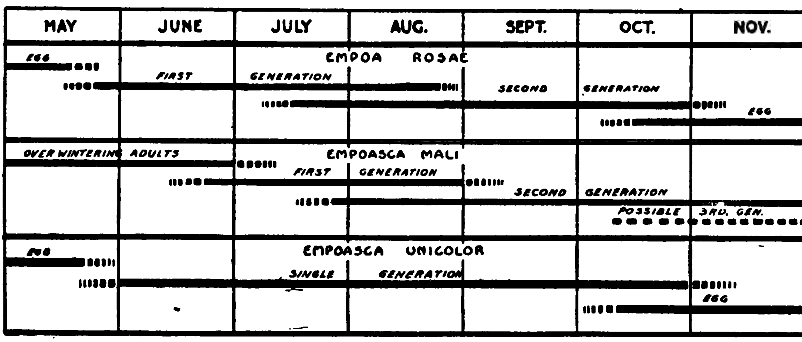

FIG. 2.—DIAGRAM OF LIFE HISTORIES AS OBSERVED AT GENEVA, N. Y.

There was considerable variation in the ages of the nymphs of this first generation, and the more advanced transformed to adults in early July. By the middle of July the great majority of the nymphs were in the later instars and the adults were becoming very numerous. Nymphs of the second generation began to appear during the latter part of the month, but the increase in the numbers of adults was more rapid than the increase in the numbers of the nymphs, so that during early August the adult was the greatly predominating form and the apple was almost free of nymphs. During the first half of August nymphs of the second generation gained the ascendency, and it was during this period that the earliest adults of the second generation appeared. By late September adults were very abundant, and most of the nymphs were of the later instars. However, all

stages of the insect continued to be present until frosts killed the remaining nymphs. It seems quite probable that these nymphs which emerged so late in the season represented a third generation from eggs by the more precocious adults of the second generation. It is doubtful if any of these reached maturity and were able to pass the winter. No evidence of oviposition in the bark of the infested trees could be found.

Empoasca unicolor.—This species spends the winter in the egg stage. The hatching occurred somewhat later than that of *E. rosæ*, and nymphs appeared during the last week in May. Development was slow as compared with the other species under observation, and adults did not appear until the first week in July. By the middle of the month all of the nymphs had matured. The insect is single brooded, and no eggs were observed until late fall, when the overwintering eggs are deposited in the bark of the apple. During the winter of 1917 further data as to the habits of the different species were obtained by bringing dormant apple branches into the laboratory and collecting the nymphs which appeared. It is a significant fact that, although nymphs of both *E. rosæ* and *E. unicolor* were thus obtained in large numbers, no specimens of *E. mali* were reared from such material.

DESCRIPTIONS OF LIFE STAGES.

EMPOA ROSÆ LINNAEUS.

The winter eggs occur in small numbers on apple, but are common on rose, and here they are frequently to be found in enormous numbers. The winter egg is deposited just beneath the bark, causing a small oblong blister. They may occur in pairs or in irregular groups, but are most frequently found singly scattered along the cane. The eggs were found most frequently to lie parallel to the axis of the stem, and may extend either upward or downward from the mouth of the puncture.

Egg.— Pale, almost colorless, translucent, with a smooth, glistening surface. In shape it is subcylindrical, curved rather sharply for about one-third its length. The curved end tapers to a bluntly rounded point, which lies next to the mouth of the puncture and represents the anterior end of the egg. The other end is broadly rounded. The average length is .792 mm. and the width .252 mm.

On the apple, the great majority of the summer eggs are deposited in the petioles and the under sides of the major veins of the leaves and are similar in appearance to the winter form.

Nymph.— This varies in color from white to almost lemon yellow in extreme cases. The early instars are generally pale yellowish, the yellow tinge usually becoming less pronounced as the nymph becomes older.

The head and thorax of the final nymphal instar are white and semi-translucent. Two dusky bristles occur on the vertex, two on the pronotum, four on the mesonotum, three on each anterior wing pad and two on the metanotum. The bristles on the thorax and the two posterior on the wing pads are set on dusky spots. The abdomen is pale creamy-white; the segments margined posteriorly with ivory white, four rows of white bristles set on ivory-white spots. The length of the body is variable, depending upon the extension or retraction of the abdominal segments, and ranges from 2.5 to 3 mm.

Adult.— Usually of a whitish color with a very slightly yellowish tinge, but varies from nearly pure white to almost lemon yellow. Eyes pearly. The face of the male is frequently washed with orange. The anterior margin of the vertex is distinctly produced to form a bluntly angular apex. Length 3 to 3.5 mm.

EMPOASCA MALI LE BARON.

Egg.— Closely resembles that of *E. rosæ* and, altho the egg of *E. mali* was found to be slightly longer, the writer has found no successful method of distinguishing them. The eggs were found buried in the major veins of the leaves, the petioles, and in the tender growing stems as well.

By bringing growing branches into the laboratory and noticing the places from which the nymphs emerged, the position of the eggs was determined. The numbers of nymphs emerging from the ten terminal leaves of ten apple branches were as follows: Leaf 1, 1 nymph; leaf 2, 2 nymphs; leaf 3, 8 nymphs; leaf 4, 27 nymphs; leaf 5, 32 nymphs; leaf 6, 21 nymphs; leaf 7, 9 nymphs; leaf 8, 1 nymph; leaf 9, 1 nymph; leaf 10, 5 nymphs. Most of the eggs are deposited on the tender portion of the shoot but not on the extreme, rapidly growing, terminal region. Below the tenth leaf

PLATE XI.— TYPICAL INJURY TO APPLE FOLIAGE BY *E. mali.*

Plate XII.— Effects of Continued Attacks by *E. mali* on Apple.

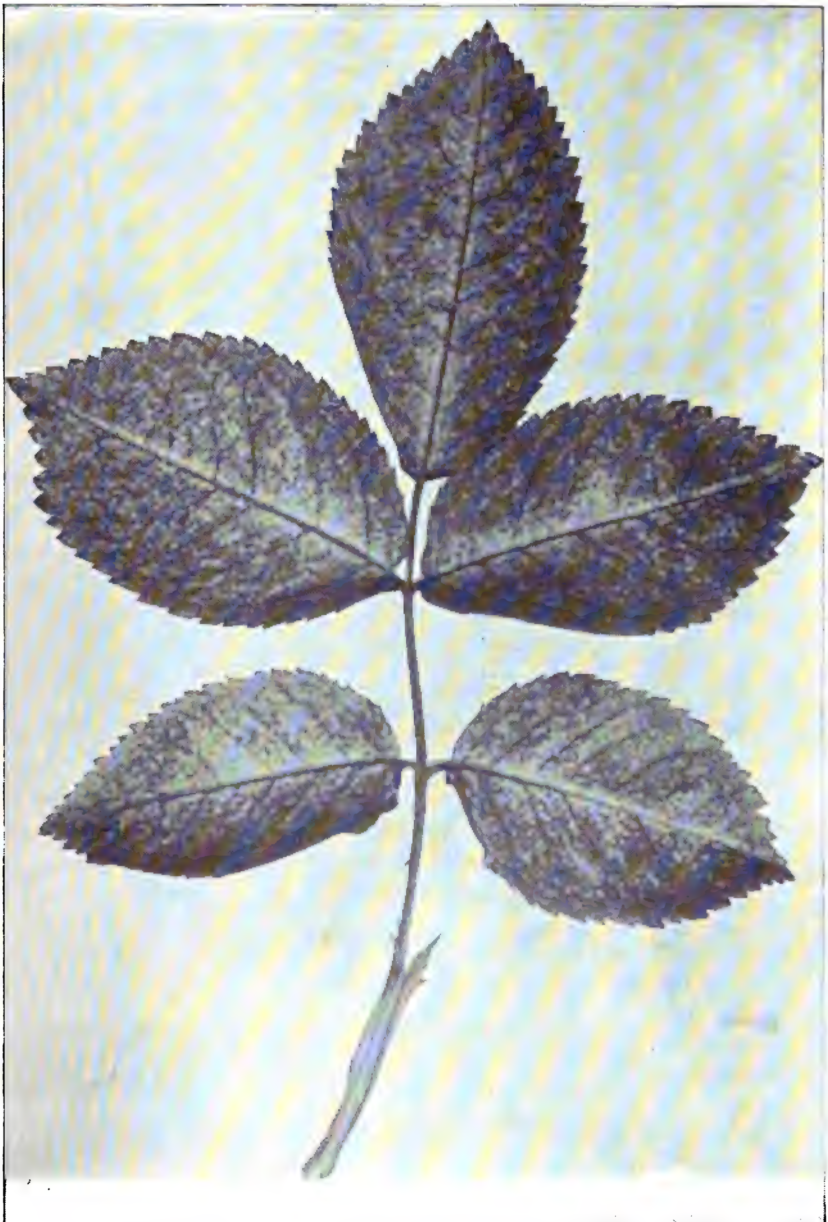

PLATE XIII.— ROSE LEAVES INJURED BY *E. rosæ*.

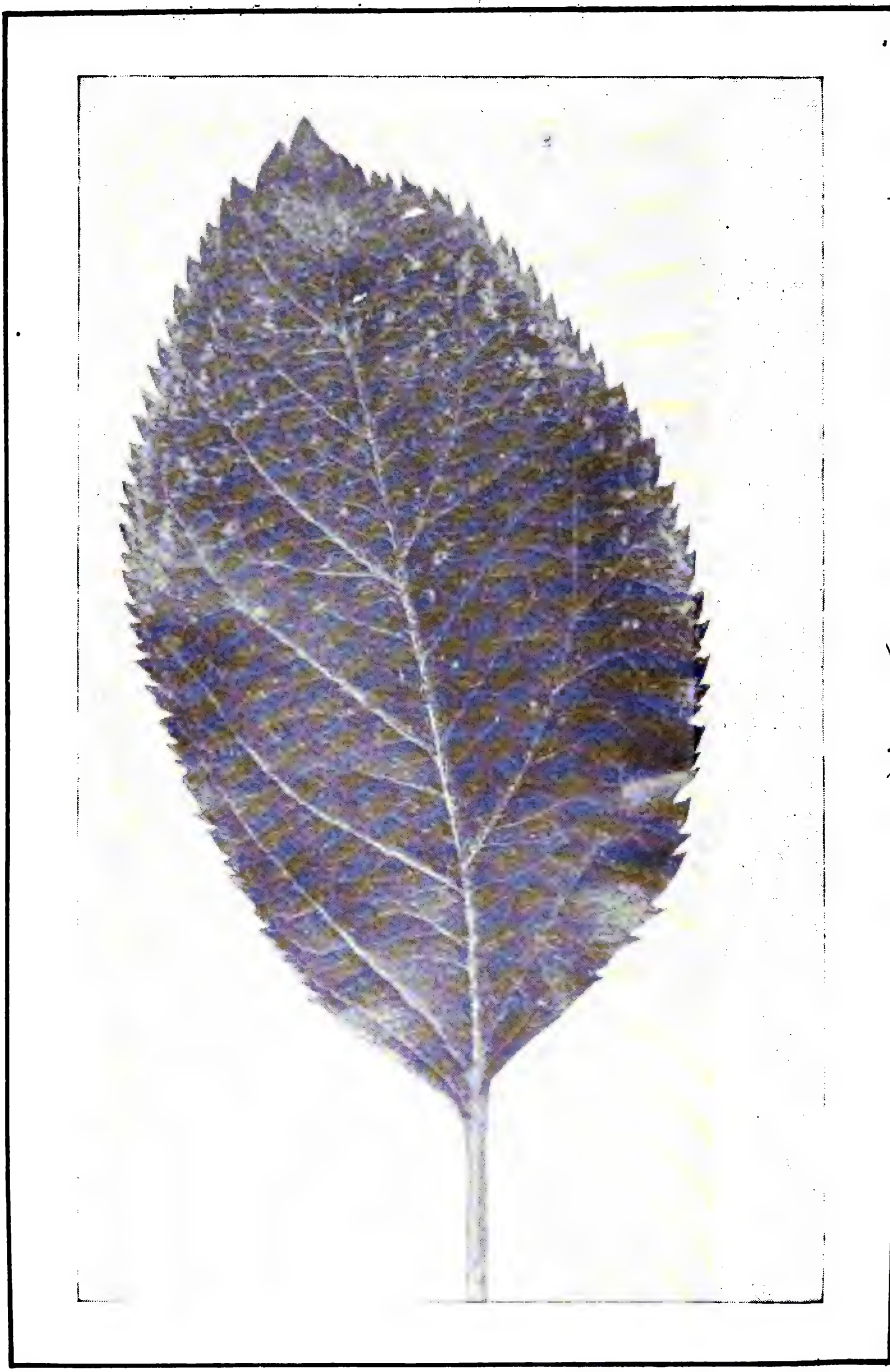

Plate XIV.—The Work of *E. unicolor* on Apple Leaf.

eggs were not so common, and only one or two nymphs were found on these nodes of the ten shoots, except in case of the twentieth node, upon which six nymphs appeared.

Nymph.— The first instar is of a pale color scarcely distinguishable from *E. rosæ*. As the nymph matures the color deepens, and the final instar is of a nearly uniform bright green hue. The eyes are pearly. The vertex is produced in a characteristic manner and in this respect it is intermediate between *E. rosæ* and *E. unicolor*. In size this species is similar to *E. rosæ*.

Adult.— Bright greenish, sometimes tinged with yellow. There are a few pale spots on the vertex and a series of six spots on the anterior edge of the pronotum, and with a pale H on the disk of the scutellum. The vertex is produced to about the same extent as that of *E. rosæ*.

EMPOASCA UNICOLOR GILLETTE

Egg.— The egg is deposited in the bark of apple and was found to occur most abundantly in growth of the previous season. Unlike *E. mali* no eggs were found in the early unfolded leaves, which indicated that hibernation is solely in the egg stage. The blisters and eggs resemble those of *E. rosæ* but are slightly larger.

Nymph.— The nymph of this species, as with the preceding form, deepens in color with age. The final instar is of a bright green color, with the anterior portion of the vertex, the sides of the pronotum, the wing pads, and the last abdominal segment strongly tinged with yellow. A rather indefinite smoky spot is apparent on each side near the middle of the front margin of the mesonotum; a blackish spot occurs on each side of the posterior margin of the mesonotum, and another pair is placed in the same position on the metanotum. A stripe of dark green extends along the dorsal meson of the abdomen.

Adult.— Bright green, marked by a longitudinal stripe on the middle of the vertex, a spot next each eye, a dash on the middle of the anterior margin of the pronotum, and a spot near the apex of the scutellum, pale greenish blue. The apex of the elytra is clouded with brownish. Unlike the adults of the other two species, the vertex is not at all produced, being no longer at the middle than against the eyes. The ultimate ventral segment of the female bears a median incision from the bottom of which rises a broad tooth. This species is slightly larger than either of the others.

HABITS AND NATURE OF INJURY.

There is considerable difference in the feeding habits of these leaf-hoppers. Both nymphs and adults of all species feed upon the under surfaces of the leaves, and it is here that they spend most of the time. When living on apple, *E. mali* is found feeding almost exclusively on the tender terminal growth, and it is perhaps for this reason that the species shows a marked preference for young, growing trees. Both *E. rosæ* and *E. unicolor* confine themselves very largely to the older leaves, and they may be found on both old and young trees. However, it was noticed that *E. rosæ* was more prevalent on older trees, while *E. unicolor* was more numerous on younger trees.

The presence of *E. mali* is at once indicated by the characteristic curling of the terminal foliage. This resembles the contortion caused by an attack of the green apple aphis (*A. pomi*) and consists of the incurling of the end and the edges of the leaf with a consequent puckering of the upper surface. (Plate I.)

In apple plots where infestation by this species has occurred for a number of years, another type of injury was noted. The young trees presented a bushy, much-branched appearance, with small ill-shaped leaves on the affected portions. (Plate II.) A possible explanation of this condition is that the injury checks the growth of the terminal shoot, with a consequent abnormal stimulation of the lateral buds, which would ordinarily remain dormant until the following summer. Garman [5] shows a very similar injury to oak caused by this species in Kentucky, and this type of injury was frequently observed on infested maple and birch in the western part of New York. It seems that this growth fails to mature properly in the fall, and is frequently killed during the winter, thereby greatly aggravating the damage caused by the insects.

The injury caused by *E. unicolor* is quite similar to that produced by *E. rosæ*. (Plate III.) The affected leaves show a characteristic white stippling of the upper surface. (Plate IV.) At the beginning of the attack these spots appear as isolated white points, most frequently along the midrib and the outer edges of the leaf. As the severity of the attack increases the spots merge and the entire leaf becomes pallid and functionless. Both of these leaf-hoppers have

[5] Garman, H., Ky. Agrl. Exp. Sta., Bul. 133, fig. 10, 1908.

a habit of constantly discharging droplets of liquid from the anus. These minute droplets fall upon the fruit and leaves, forming tiny round spots of a dark greenish or black color. This spotting of the leaves and fruit is a characteristic indication of severe infestation, and, if not removed by rain, may materially reduce the value of the fruit.

While egg punctures of *E. rosæ* do not usually exist in sufficient numbers on apple to cause serious injury, they do occur on rose in such vast numbers that the canes are not infrequently killed.

LEAF-HOPPERS IN RELATION TO FIRE BLIGHT.

Besides the direct injury which has just been discussed, field observations, as well as experimental studies, have indicated that leaf-hoppers are important agents in the transmission of fire blight of apple. Stewart and Leonard[6] found that *E. mali* is capable of introducing the organism and of transmitting it in cages when pure cultures had been smeared on leaves of some of the shoots.

The writer conducted a series of experiments in an endeavor to ascertain more conclusively the role of these insects in the transmission of the disease. Rapidly growing, two-year-old apples in the greenhouse were selected. Growing shoots of these trees were inoculated with the organism obtained from the exudate from infested trees in the orchard. These shoots were then enclosed in wire frames covered with a fine black silk gauze. When the symptoms of the disease had appeared the leaf-hoppers were introduced and allowed to feed. After feeding on the diseased tissues for some time the insects were transferred to similar cages over healthy growing shoots. Healthy shoots reserved as checks were caged in a similar manner but were either allowed to remain free of insects, or merely exposed to the attacks of leaf-hoppers which previously had not been placed upon diseased tissues. The following notes give the principal details and results of the experimental activities:

Experiment No. 1.— July 1, 1916. Apple shoot "A" inoculated with *Bacillus amylovorus* secured from an infected orchard tree.

July 5, 2:00 P. M. Ten adults (*E. unicolor*) placed on the blighted twig.

[6] Stewart, V. B., and Leonard, M. D., Phytopathology, VI: 154, 1916.

July 6, 8:30 A. M. Five adults transferred to healthy shoot in cage No. 1.

July 6, 2 P. M. Three of adults allowed to remain on twig "A" are dead. The two living specimens were then transferred to healthy shoot in cage No. 2. No disease developed from either of these transfers.

Experiment No. 2.— July 1, 1916. Apple shoot "B" inoculated with *B. amylovorus* secured from infected orchard tree.

July 6, 2 P. M. Three adults (*E. unicolor*) placed on the blighted twig.

July 7, 8 A. M. One of the leaf-hoppers is dead. Two transferred to healthy shoot in cage No. 3. These specimens had been feeding on green parts of the diseased shoot. Feeding on healthy shoot began as soon as the transfer was made.

July 11. One of the leaf-hoppers in cage No. 3 is dead. Small black area on the underside of one leaf may be incipient infection of the disease. No further development of the disease occurred, and regarded this case as doubtful.

Experiment No. 3.— July 1, 1916. Apple shoot "D" inoculated with *B. amylovorus* secured from infected orchard tree.

July 13. Shoot "D" just beginning to show decided wilting. Thirty nymphs (*E. mali*) of all instars placed on the shoot.

July 15. Fourteen of these nymphs were transferred to healthy shoot. The others had died or were lost in transferring. A number of the nymphs were feeding on the shoot just prior to being transferred, and all commenced feeding immediately after the transfer.

July 17. Darkened areas noted on two leaves.

July 18. Diseased areas spreading rapidly and large areas of other leaves affected. The disease continued until the entire shoot was blighted.

Experiment No. 4.— July 8, 1916, 8:30 A. M. Apple shoot No. 100 inoculated from pure culture of *B. amylovorus.*

July 18, 11:00 A. M. Leaves of shoot No. 100 badly wilted, tip practically dead, exudate coming from midrib of one leaf in moderate quantities. Fifteen adults (*E. unicolor*) placed on the shoot.

July 18, 3 P. M. All but one of the above adults dead. This one transferred to healthy shoot. No disease developed.

Experiment No. 5.— July 18, 1916. 4 P. M. Eight nymphs (*E. mali*) placed on blighted shoot No. 100 (See Exp. No. 4).

July 19. Two of above transferred to healthy tissues. No disease developed.

Experiment No. 6.— Shoot inoculated with culture of *B. amylovorus.*

July 22, 12.00 A. M. Nymphs (*E. mali*) placed on the above twig.

July 24, 9:30 A. M. Shoot wilted, shows brownish discoloration and a small amount of exudate on the stem. Six of the nymphs transferred to healthy shoot.

July 31. Two leaves wilted, another shows blackened area on edge.

August 11. Blight has spread to include the edges of six leaves. Entire shoot badly wilted.

Experiment No. 7.— July 21, 1916. Apple shoot inoculated with *B. amylovorus* secured from exudate from apple shoot.

July 25, 11:15 A. M. One of terminal leaves blackened and wilted, stem somewhat discolored. Nineteen nymphs of *E. rosæ* placed on blighted twig.

July 27. Nine of the nymphs dead. Ten transferred to healthy shoot. No disease developed.

Experiment No. 8.— July 21, 1916. 4:30 P. M. Apple shoot inoculated with *B. amylovorus* secured from exudate from apple shoot.

July 25, 11:35 A. M. One terminal leaf somewhat wilted and stem discolored. Thirty nymphs (*E. mali*) placed on this blighted shoot. (See Exp. No. 9).

July 26, 9:30 A. M. Ten of above nymphs placed on healthy shoot.

August 11. Shoot blighted, leaves blackened and terminal growth wilted.

Experiment No. 9.— July 21, 1916. 4:30 P. M. Apple shoot inoculated with *B. amylovorus* secured from exudate on apple shoot.

July 25, 11:35 A. M. One terminal leaf somewhat wilted and stem discolored. Thirty nymphs (*E. mali*) placed on this blighted shoot. (See Exp. No. 8).

July 27, 4:30 P. M. Fifteen nymphs dead. Remaining five transferred to healthy shoot. No disease developed.

Experiment No. 10.— July 21, 1916, 4:30 P. M. Apple shoot inoculated from culture of *B. amylovorus.*

July 25, 12:00 M. Thirty-eight adults (*E. unicolor*) placed on this blighted shoot. Stem shows some discoloration, but no wilting yet.

July 26, 9:45 A. M. Eleven of these nymphs transferred to blighted shoot occupied by nymphs used in Exp. Nos. 8 and 9.

July 27, 4:00 P. M. Only two of the nymphs remain alive. These transferred to healthy shoot. No disease developed.

It will be seen from the above that it was found possible to transfer fire blight by means of the nymphs (*E. mali*) which had been allowed to feed on infected tissue. Except in one doubtful instance transferring nymphs of *E. rosæ* and adults of *E. unicolor* from infected to healthy shoots did not result in infection by the disease. The insects in feeding avoided the diseased tissues as much as possible, and the high mortality of the adults of *E. unicolor* enclosed upon the diseased shoots would seem to indicate that feeding upon blighted tissues is injurious to the leaf-hoppers, for the creatures were kept alive without difficulty upon healthy shoots.

The negative results should not be taken to indicate that species other than *E. mali* are incapable of transmitting the disease.

NATURAL ENEMIES.

Various parasites and predators attack the leaf-hoppers. The numerous small spiders inhabiting the infested trees were observed to feed on the leaf-hoppers and are probably of considerable importance in reducing the numbers of these insects. Dryinid parasites were observed on all three species, but in no case were they sufficiently numerous to be considered of much importance.

The egg parasite,[7] *Anagrus armatus* Ashmead, of *E. rosæ* was very common during the summer of 1916 and was a very effective enemy of the leaf-hopper.

CONTROL MEASURES.

For the protection of apple foliage, especially of nursery trees or of newly-planted orchards, chief reliance should be placed on soap and nicotine mixtures of standard strengths. In spraying, the application should be made when the maximum number of nymphs in the younger stages are present, with fairly high pressure, using

[7] Identified by Mr. A. A. Girault of the U. S. Bureau of Entomology.

nozzles with large apertured discs. Sufficient material should be used to thoroughly wet the undersides of the leaves and, generally speaking, the most satisfactory results can only be obtained by drenching the insects. With nursery stock and young trees, immersion of the growing tips into a receptacle containing a quantity of the spraying material is an efficient method of treatment.

In a series of spraying tests in which soap, nicotine, and kerosene emulsion were also compared, a high degree of effectiveness was indicated for a spraying mixture composed of nicotine sulphate 1 pint, lump lime 60 pounds, copper sulphate 4 pounds, and water 100 gallons. The copper sulphate was dissolved in four gallons of water, and then the lime was slaked to form a thin paste. These were then mixed together and diluted with water to make the required amount, after which the nicotine sulphate was added. After straining the lime through a fine metal sieve into the tank, during which operation the agitator was kept in action to secure an even distribution of the materials, the suction intake was placed in the tank, when spraying was immediately undertaken. This formula, or some modification of it, as may be suggested by future experience, will probably be found to have as its chief field of usefulness the treatment of young non-bearing orchards where it is desired to combat the green aphis as well as leaf-hoppers.

For bearing orchards experimental data are needed establishing the practical value of spraying and the conditions under which the operations should be undertaken to secure results against the different species of leaf-hoppers commensurate with the outlay for labor and materials. In the Station plats the benefits from applications of the foregoing insecticides to control *E. unicolor* and *E. mali* have not been very marked, which may be explained on the ground that the injuries have not been extreme and the comparatively slight damage to terminal growth on bearing trees by *mali* seems not to have appreciably influenced crop production. While *E. rosæ* would be of greater importance in bearing orchards, the necessity for special applications to control even this species has not appeared to be very urgent in this locality during normal seasons. One phase of this problem should, however, not be overlooked and that is the activities of the leaf-hoppers in transmitting fire blight. Proof of a vital relationship between these agents and the demonstration that the different leaf-hoppers are an essential or an important element

in the spread of the disease during midsummer would certainly prove additional incentives to growers to adopt some system of spraying, aiming either at the individual or collective control of the insects.

Mention has been made of the fact that *E. mali* breeds on a large number of plants, including various weeds. To remove vegetation that harbors the insects orchards should be cultivated or mowed to prevent the growth of weeds. Attention is also called again to the fact that *E. rosæ* breeds abundantly on currants and gooseberries, which should be considered in any plans that provide for the interplanting of apples with these bush fruits.

EXPERIMENTS FOR THE CONTROL OF THE GRAPE ROOT-WORM.*

F. Z. HARTZELL.

SUMMARY.

The grape root-worm has been the most destructive pest of vineyards in the Chautauqua and Erie grape region during the past two decades.

Previous to the studies herein described, the chief method of control sought the destruction of the adults by arsenical sprays alone or in combination with bordeaux mixture. Two applications during the latter part of June or early July were usually advised.

Owing to the failure of this system of treatment in the hands of many grape growers, the field tests discussed in this bulletin were conducted to determine the causes of failure, and on the basis of this knowledge to devise efficient and practical methods of combating the pest.

Trials of sprays were made in vineyards, the plats being nearly an acre in extent, and no plat was less than five rows wide. The plats to be compared were in the same section, and, with one exception, they were placed parallel to each other. It was necessary to have the plats of the width mentioned in order to avoid error due to the influence of the several treatments on the beetles.

Spraying was accomplished by means of either horsepower or gasoline engine outfits fitted with three cyclone nozzles on a side. The nozzles were set to cover the foliage properly, and, once adjusted to a row, were operated without further change.

It was found that a comparison of yields of plats gave inaccurate data regarding the effect of treatment on the grape root-worm; therefore the numbers of eggs deposited by the beetles on the several plats were compared as measures of the efficiency of the applications. This necessitated taking a sample in each plat. Usually

* Reprint of Bulletin No. 453, December, 1918.

ten vines were selected in each plat, and the eggs counted. The selection of the vines was made in such a manner as to avoid systematic error of infestation.

Efforts were made to avoid errors in the collection of the data, and the probable error of the mean was calculated for each plat. The probable error of the difference in the number of eggs between two plats was used to determine the degree of certainty that could be placed in the results. Since the number of observations upon which each mean was calculated was rather small, an indirect method of calculating the probable error has been used.

In the field tests during 1910 it was learned that molasses was very attractive to the beetles. Its use with arsenate of lead made a combination destructive to the insects. The development of a practical method of using the sweetened spray and comparative tests of this material with bordeaux mixture and poison were the chief objects of the experiments since 1910.

Two sprayings with bordeaux mixture and arsenate of lead, thoroly applied at the proper time, have given effective control of the grape root-worm. The effectiveness of the spraying is more pronounced when the treatment is continued over several seasons. Failures to combat the beetle satisfactorily are largely attributed to delay in making the applications, allowing too long an interval between the first and second applications, and lack of thoroness due to poor spraying apparatus, dense foliage or spraying in windy weather.

Poison was found to be of importance in the bordeaux mixture.

The use of molasses and arsenate of lead applied at a time when rains did not occur for several days, followed in a week or ten days with bordeaux mixture and arsenate of lead, proved more efficient in controlling the grape root-worm than two applications of the latter mixture.

The addition of molasses destroys the adhesiveness of the arsenate of lead, thus necessitating the precaution of applying the material at a time when the weather conditions indicate that no rain is to be expected for several days. A supplementary treatment should be made in about one week with bordeaux mixture and poison to protect vines from invading beetles.

Two gallons of molasses in each 100 gallons of spray produced better results than one gallon.

A combined spray for the grape leaf-hopper and the grape root-worm was not found practical, owing to the fact that, during the seasons when the tests were made, the periods for effective control of the two insects did not coincide. However, the use of nicotine sulphate with bordeaux mixture and arsenate of lead did not injure Concord grape foliage in any instance.

Glucose was not found to be as effective as molasses with arsenate of lead.

Arsenite of zinc when used either alone or with molasses severely injured grape foliage.

The adults of *Fidia viticida* were found to fly with the wind.

During certain seasons the numbers of grape root-worm larvæ were greatly reduced thru the activities of Carabid beetles.

On the basis of the experiments described, two methods of control are recommended: (1) Molasses, 2 gallons, arsenate of lead, 6 pounds, and water 100 gallons, followed in about one week with an application of bordeaux mixture (8–8–100) and arsenate of lead 6 pounds; (2) two applications of bordeaux mixture (8–8–100) and arsenate of lead, 6 pounds at an interval of about ten days. The first system of treatment is especially recommended when the beetles are present in excessive numbers, but the second is advised for general vineyard spraying when beetles are not abundant.

INTRODUCTION.

The grape root-worm (*Fidia viticida* Walsh) has been the most serious pest of vineyards in the Chautauqua and Erie region of New York and Pennsylvania. This bulletin is a detailed account of control experiments conducted against this insect for six seasons. In the beginning of the investigation it was aimed to test chiefly the value of bordeaux mixture and arsenate of lead for the control of the root-worm, but owing to the favorable results obtained with sweetened poison against other insects, tests were also made with this material. During 1910 and 1911 the results with molasses and poison were very favorable, while in 1912 and 1913 the sweetened spray proved much less efficient. In succeeding years, principally during 1914 and 1915, efforts have been directed toward ascertaining the causes of the failures and the conditions under which the foregoing spraying mixtures could be most profitably used. In the course of these

investigations supplementary experiments were made both in the field and laboratory, the results of which, because of their practical importance, are presented in this bulletin.

Owing to the fact that biometrical methods have not generally been employed in considering the evidence of field experiments, and as it was desirable to resort to statistical analysis in the interpretation of our data, the application of some of the principles of biometry in this study is briefly considered.

PART I. LIFE CYCLE, HABITS AND IMPORTANCE OF THE GRAPE ROOT-WORM.

LIFE HISTORY AND HABITS.

The grape root-worm is not a worm according to zoological classification, but is the larva of a beetle. The adults (Plate I, fig. 1, Plate II, fig. 2; and Fig. 1) are robust in appearance, and are grayish-brown in color. The beetles vary in size, but average about one-fourth inch in length. In Chautauqua County, N. Y., they appear on the foliage of the grape during the latter part of June or early July, the time depending upon weather conditions. The feeding of the beetles, which produces characteristic chainlike markings on the leaves (Plate II, fig. 3), is most active for about two weeks after emergence. After feeding about a week, the sexes mate, and soon afterwards the females begin laying eggs. Oviposition continues until early August, altho certain belated females may deposit eggs until near the end of that month. The eggs (Plate I, fig. 2) are deposited under the loose bark of the entire vine, except the roots, the majority being placed on the canes. From these eggs, in about two weeks, hatch cream-colored grubs, which are about .04 of an inch in length. These drop to the ground soon after hatching, and burrow until they find the roots of the vine upon which they feed. They are voracious feeders during the late summer and autumn, and usually attain full growth by the last of October (Fig. 2 and Plate I, fig. 3). About this time they burrow to a depth of a foot or more, and form circular cells

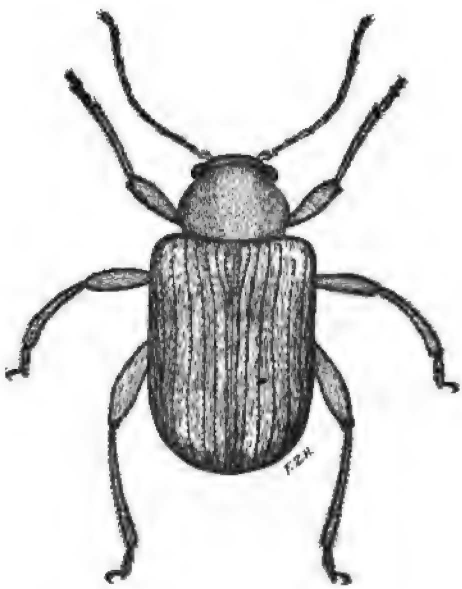

Fig. 1.— ADULT GRAPE ROOT-WORM.
(Much enlarged.)

in which they pass the winter. In the early part of May the grubs leave their winter quarters and crawl nearer the surface. The full grown larvæ seldom feed during the spring — altho undeveloped larvæ do feed — and the early part of June the majority of grubs form cells from four to eight inches beneath the surface of the soil where they change to pupæ (Fig. 3 and Plate I, fig. 4) the first beetles emerging about June 25 in a normal year. The time of appearance of the first adults, which is determined by conditions of season and soil, may be as early as June 17 and as late as July 14. The majority of the beetles usually emerge about a week after the appearance of the first individuals, but during certain seasons there

Fig. 2.— LARVA OF GRAPE ROOT-WORM.
(Much enlarged.)

Fig. 3.— PUPA OF GRAPE ROOT-WORM.
(Much enlarged.)

may be a longer interval. The adults, after mating and laying eggs, die in the latter part of July and early August, altho occasional beetles may be found as late as the second week of September. Rarely an individual will require two seasons to reach the adult state, in which event pupation takes place the second season. A diagrammatic representation of the normal life history is shown in Fig. 4.

ECONOMIC IMPORTANCE.

In the early literature of this species, mention is made of serious damage to vines by the beetles destroying the foliage, but our observations record only a single instance of serious injury to grape foliage. In this case damage was due to the pulling out of a seriously infested section in the spring, so that the beetles emerging during July were

forced to concentrate on the nearest vines. The most serious injury to the growth of the vine is caused by the feeding of the larvæ on the small, fibrous rootlets and on the bark and cambium layer of the roots. They channel the older roots and, when present in sufficient numbers, girdle them (Plate III). These grubs thus kill the portions

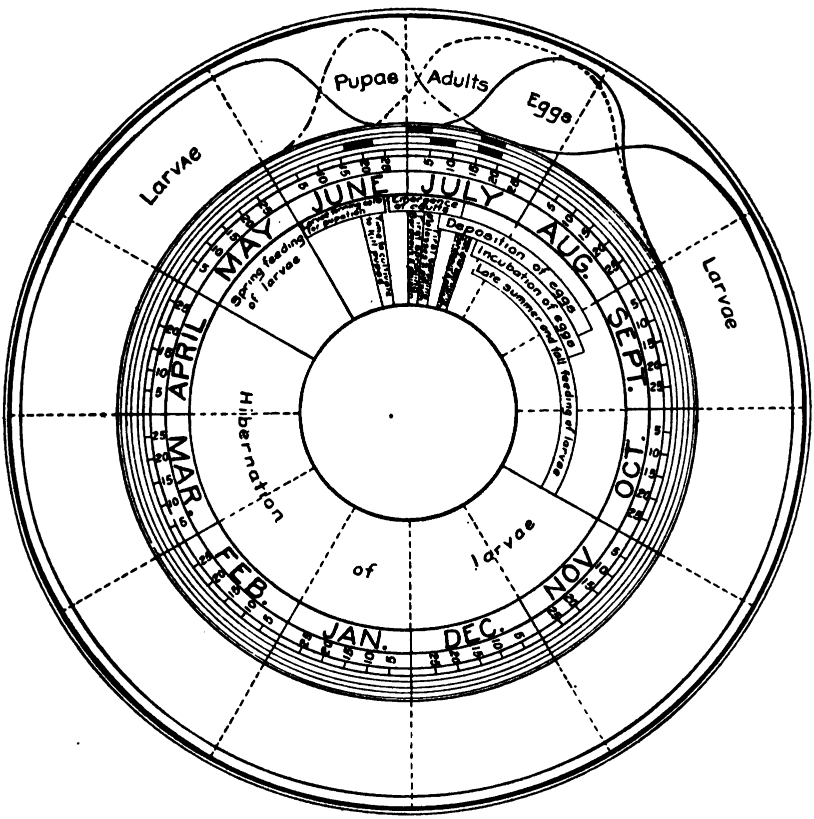

Fig. 4.— DIAGRAM SHOWING THE SEASONAL HISTORY OF THE GRAPE ROOT-WORM DURING A NORMAL SEASON.

of the roots where absorption of food and water takes place, and also destroy the channels which conduct this material to the main trunk. Often the entire root system is destroyed with a consequent loss of the vine, but *the more usual effect* is to seriously weaken the vine, so that it succumbs to disease or, if it does eke out an existence,

produces little or no profit to the owner (Plate V). Occasionally a vineyard is practically destroyed by the beetle, but this is exceptional (Plate IV). The greatest damage that has been done recently in western New York is the weakening of the vines on thousands of acres which has reduced their productive value, and has resulted in great financial losses to owners of such plantings.

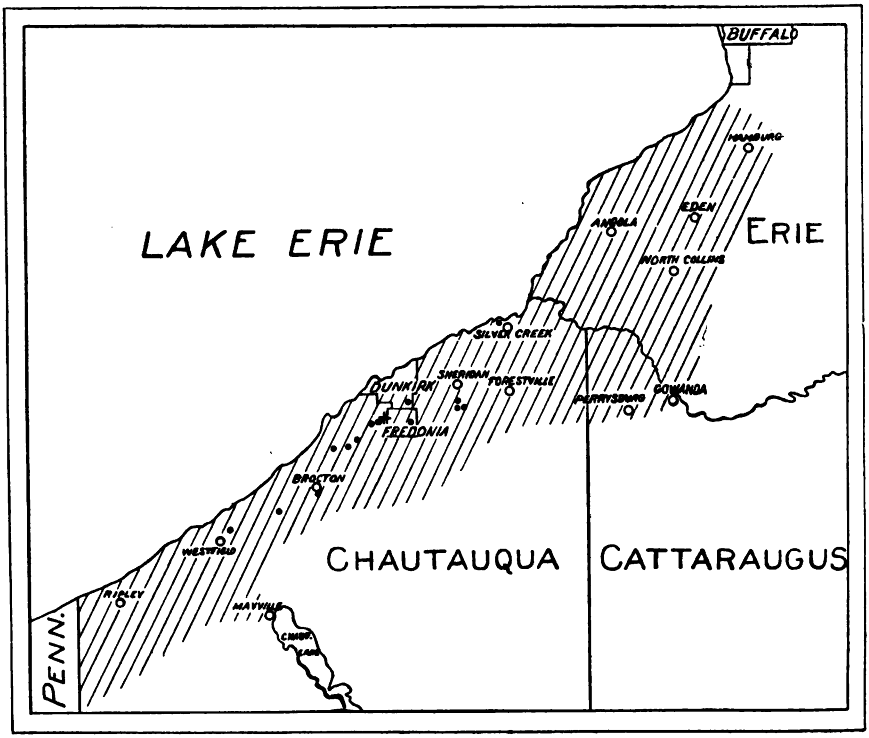

Fig. 5.— MAP SHOWING THE NEW YORK PORTION OF THE CHAUTAUQUA AND ERIE GRAPE REGION.

The shaded part indicates the area in which grapes are grown commercially but the proportion of tillable soil planted to vineyards varies in different portions of the area. Dots represent the location of co-operative experiments for the control of the grape root-worm. Cross indicates location of Vineyard Laboratory and Station vineyards.

It is estimated that the vineyards in Chautauqua, Cattaraugus and Erie counties total 35,000 acres and over all this area the grape root-worm is present in varying numbers. A map of the Chautauqua and Erie grape belt in New York is shown in Fig. 5. During periods

when these insects are very numerous the vineyards suffer considerably from their depredations. It is impossible to state the exact money loss that has occurred in the 16 years from 1900 to 1916, during which time the root-worm has been known to cause serious damage in these vineyards, but it is known that this insect has been an important factor in the decline of the vineyards. If they were present in only 20,000 acres in sufficient numbers to cause a yearly loss of only $5.00 per acre for the 16 years mentioned, it would mean a loss of $1,600,000, or $100,000 annually, to the vineyardists of Chautauqua, Cattaraugus and Erie counties. The actual loss, no doubt, has been several times this sum.

This insect was the cause of so much damage in Ohio vineyards during the 90's, that many growers pulled out their vines, and engaged in other lines of farming.[1] The injuries to vines in Erie County, Pa., has been very serious, for the root-worm seemed to have caused damage here earlier than in Chautauqua County and, since the acreage is large, the monetary loss must have been considerable.

The reasons for the difficulty in estimating the exact amount of grape root-worm injury are the following: (1) Most vineyards have declined because of the destruction of humus without subsequent additions; (2) no system of fertility has been practiced in most of the vineyards which would replace plant food used by the growing vines and this has allowed a decline; (3) the lack of cover crops on the steep hillsides, especially on the shale soils, has allowed much washing of the soil to take place, and many vineyards which formerly were profitable are now in such poor condition that the financial returns are small. How much weight should be given to each of these causes it is impossible to say at present, for each one, together with the root-worm injury, has had an important share in causing the general decline in production which has been so apparent for nearly two decades.

HISTORY OF REMEDIAL MEASURES.

The study of any important pest of a cultivated crop is seldom the result of the investigations and observations of any one person, and generally many workers contribute a share to the solution of the problem. Each worker usually takes up the study where it

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[1] Felt, E. P. Grapevine root-worm. N. Y. State Mus. Bul. 72, pp. 9–11. 1903.

was discontinued by his immediate predecessors. The knowledge of the life habits and methods of control of the grape root-worm (*Fidia viticida* Walsh) which we now possess is no exception to this rule.

This insect has been known to science and to vineyardists for more than forty years, and when the author began his investigations in June, 1909, much had been accomplished by other investigators in solving the riddle of the life history and control of this pest. Notwithstanding, the grape root-worm remained the most serious insect enemy of the Chautauqua County vineyards, and grape growers were pessimistic regarding their ability to control it by the methods then recommended. The fact that many growers reported failure to control this enemy, therefore, made necessary experiments to test the practicability of the various methods of control which were advocated and, if possible, to improve them if they were found inadequate. In justice to other workers who have labored with this insect, we will state that much of the failure of the growers to control the pest arose from improper applications of sprays and especially the lack of appreciation of the proper time to make the treatments. Another important cause of failure was the fact that sprayings were not continued over a sufficient number of seasons to secure the cumulative effects that accrue from proper spraying for several consecutive seasons.

The life cycle of the grape root-worm was first investigated and described by F. M. Webster [2] in 1895, who found the insect in injurious numbers near Cleveland, Ohio. From these life history studies it was evident that the most successful method of control would be the prevention of egg deposition on the vines by the adults, and the most practical method to secure this was by killing the adults or by repelling them from the vines. The next step was to devise efficient sprays and ascertain the time of maximum effectiveness of the applications. His remedial recommendations were arsenical sprays to kill the adults. The extensive experiments of Slingerland,[3] Craig,[3] Johnson,[4] and Felt [5] during the seasons of 1902 to 1904 showed that, while in some instances unsatisfactory results were secured, spraying with arsenate of lead and bordeaux mixture

[2] Webster, F. M., Ohio Agr. Expt. Sta. Bul. 62. 1895.
[3] Slingerland, M. V., and Craig, J., Cornell Agr. Expt. Sta., Bul. 208. 1902.
[4] Slingerland, M. V., and Johnson, F., Cornell Agr. Expt. Sta., Bul. 224. 1904.
[5] Felt, E. P., N. Y. State Mus. Bul. 59, 1902, and Bul. 72. 1903.

proved to be an efficient method of preventing oviposition by the adults. Felt also recommended cultivation during June to kill the pupæ as well as collecting the adults by beetle catchers.[6] The experiments of Johnson and Hammar,[7] 1906–1909, also proved that arsenate of lead with bordeaux mixture will control the pest if the remedy is continued over several seasons.

When the author began the entomological work at Fredonia, in June, 1909, the root-worm beetles were rather scarce in all vineyards which it was possible to visit in the short period between emergence and the proper time to spray, and so attention was directed to life history studies of this and other insects that attack the grape. During that season, talks with numerous growers all pointed to the fact that most of them doubted the efficacy of the bordeaux-arsenate of lead spray for the control of the grape root-worm. The existing situation pointed clearly to the fact that well planned and long-term field experiments were necessary before any definite progress could be made in the solution of such a difficult problem. The experiments soon revealed the fact that considerable variation in effectiveness is to be expected with most spray materials used against the grape root-worm. Bordeaux mixture and arsenate of lead in combination are usually effective when properly applied, but dense foliage and wind often make it extremely difficult, even for expert workers, to thoroly spray a vineyard. Under such conditions the number of beetles may not be sufficiently decreased in one season to encourage the average grower to continue the practice. The failure to overcome these difficulties largely accounts for the reluctance of vineyardists to resort to spraying in an effort to keep the pest under control.

A mixture of glucose and arsenate of lead was used in Chautauqua County against the rose chafer with excellent success during the early part of June, 1910. Similar experiments against the grape root-worm seemed to produce rather poor results; for which reason molasses was substituted for glucose in all subsequent experiments

During six seasons, from 1910 to 1915 inclusive, experiments were conducted with both the bordeaux mixture-arsenate of lead and molasses-arsenate of lead combinations; also with other insecticides with the object of securing the most efficient control of the

[6] Felt, E. P., N. Y. State Mus., Bul. 72, pp. 34–38. 1903.
[7] Johnson, F., and Hammar, A. G., U. S. Bur. Ent., Bul. 89. 1910.

grape root-worm. In the course of these efforts it was learned that the effectiveness of molasses and arsenate of lead depended to a large extent upon the condition of the weather following the spraying. Rains were found to wash much of the material from the foliage, which subsequent studies showed was due to the fact that molasses practically destroys all the adhesive properties of arsenate of lead. In spite of this reaction it was considered desirable to test still further the poison bait since, under certain conditions, it possesses desirable properties.

The dispersion of the adults during the period of oviposition proves also to be an additional disturbing factor in the control of this pest. It was found that vines sprayed with molasses and arsenate of lead were frequently freed from the beetles which were present at the time of spraying, but if rains followed the application within a week, the arsenical was washed off the foliage, thus leaving the vines exposed to attack. Frequently beetles reinvaded such a planting and in spite of the treatment would lay many eggs. To provide against this contingency it was found necessary to supplement the sweetened spray by a treatment, about one week after the application, with bordeaux mixture and arsenate of lead to repel all immigrating beetles. This work features prominently in the experiments of 1914 and 1915.

PART II. METHODS OF EXPERIMENTATION AND COLLECTING OF DATA.

OBJECT OF FIELD TESTS.

The first aim of the field trials with the insecticides, which are later described with considerable detail, was to compare the number of eggs laid by the beetles in a plat treated with a certain combination with the number deposited in the plats receiving no treatment, or sprayed with various miscellaneous mixtures. Then again it was desirable to determine the practicability of using the various mixtures under field conditions considered from the standpoint of their action in the sprayers, and possibility of uniformly covering the foliage to insure control of the pest. The ultimate object in all of these activities was to determine which system of treatment gave the best results against the root-worm.

NATURE OF EXPERIMENTS.

All the experiments described in this bulletin, except the tests dealing with the question of adhesiveness, were made in commercial vineyards, and the material was applied with fixed nozzles attached to either a horse-power sprayer or a gasoline engine outfit (Plates VII and VIII). A few of the tests were carried out in the Station vineyards, but the majority of the trials were conducted in vineyards of private owners. In the latter the experiments were made on a co-operative basis. The Station contributed the spraying materials and assistance in the application of the spray, while the grower furnished the sprayer, team, driver and mixing receptacles. In a few instances the owner furnished the spraying materials but asked for direction in the application of the materials. Because of the expressed desire to determine on their own premises the worth of the different mixtures, these vineyardists permitted the writer to plan the necessary test plats.

SIZE, SHAPE AND LOCATION OF PLATS.

The usual size of the sprayed plats was approximately one acre. To be exact, in the majority of cases, it was the area of the vineyard that was sprayed with the contents of a 100-gallon spray tank. The check plat was usually as large as a single sprayed plat. On

the Station vineyard the plats were occasionally only one-half acre in extent. The width of the plats varied in the different vineyards owing to the variation in the lengths of the rows. In the Chautauqua and Erie grape belt the vineyards are divided into sections, each row averaging nearly fifty vines and of a length of four hundred to five hundred feet, depending on the distance between vines. Frequently the rows were shorter or longer than the measurements given. Naturally, the longer the rows the less the number necessary to furnish the desired area, and thus the widths of the acre plats varied slightly. The writer deems it necessary to have plats at least five rows wide but even wider plats are desirable. The object of having moderately wide plats is to avoid — at least as far as possible — the attractive or repellent effects of the material of one plat on the beetles of a neighboring plat. On the other hand, if the plats are too wide, the variation in the infestation from one side of the section to the other may introduce a systematic error.

THE QUESTION OF CHECK PLATS.

The idea of a check or control test or, as it might be called, a blank test in an experiment is in common use in chemistry, field tests of fertilizers, and spraying for fungous diseases and insect pests of plants. Since such experiments usually consist of a comparison between treated and untreated portions of the material, the check is an essential part of the experiment. A blank test to be of greatest worth must not be influenced even in the smallest degree by the other portions of the experiments, or its value is decreased. In a chemical experiment or a test of fertilizers, especially on level ground, this desideratum is usually attained satisfactorily because exterior conditions influence all plats alike. The greatest difficulty to be considered in such experiments is the variability of the chemicals, or the soil. With certain plant diseases, like powdery mildew of the grape, if the disease has become established before treatment is applied, one can determine the uniformity of the infection and treat certain plats, leaving others, having the same amount of the fungus, untreated. With all these apparently uniform conditions some variation in results is unavoidable in plats treated alike, due to a number of causes, such as impurity of fungicidal materials, lack of uniformity in the plats, errors in determination of the results, etc. The economic entomologist, who is experimenting in the control of flying insects,

has to contend with all these factors, and in addition he is confronted with another difficult problem; as the insects may move from treated plats to the untreated plats in case a repellent is used, or from the untreated plats to treated plats when a strongly attractive substance is applied near enough to the check plat to exert such an influence. If the material is neutral, so far as attractive or repellent properties are concerned, but is toxic, then as the insects die off in the sprayed plats those on the check plats would have a tendency to spread into the sprayed plats. In any event, the number remaining on the check plat at the end of the experiment would not be the same as at the beginning. Thus the value of the blank test is marred, and conclusions drawn from such experimental data are incorrect to the degree that the disturbing influences exist, unless due allowance has been made for them. These difficulties are hard to overcome, and one of the problems confronting the author has been to provide for satisfactory checks in the efforts to secure control of the grape root-worm.

If bordeaux mixture and arsenate of lead are used on one plat and the spray applied so thoroly that scarcely a leaf remains uncovered, and the adjoining plat is untreated, the beetles, if they are repelled by the material, will leave the sprayed vines, and fly to the checks. In the Chautauqua region this is even more apt to occur if the untreated plat is to the east of the treated plat, owing to the insects flying with the wind and to the prevailing winds being from the west and southwest. In such an instance the difference between the number of eggs on the two plats would not be a true index of the destruction of the beetles on the sprayed plat, but would only indicate to what extent they were driven to the check plat. On the other hand, if molasses and arsenate of lead were used on one plat, and the beetles were attracted to this material, and there is good evidence that this is true, the adjoining unsprayed plat would suffer diminution in numbers. Even tho all such migrating insects were poisoned before they laid eggs, the difference in number of eggs in the two plats would not truly indicate the efficiency of the molasses spray.

While we are convinced that, on the warmer days at least, the molasses does attract the beetles, the proof that the bordeaux mixture repels the insects is not so positive. When foliage sprayed with the latter mixture and unsprayed foliage are placed together in a cage

with a number of the beetles, the insects feed on the unsprayed leaves, and avoid those that have been treated. Examinations for six years of the ground beneath vines sprayed with this mixture have revealed only two dead beetles, even tho at times sheets have been placed under the vines to facilitate observation of the dead insects. At the same time dead beetles were found in considerable numbers under the vines sprayed with molasses and arsenate of lead in the same vineyards. As a rule the beetles disappeared from the vines properly sprayed with either mixture, provided, in the case of the molasses spray, suitable weather followed the application. The apparent repellent effect of the bordeaux mixture and arsenate of lead was most marked on vines whose foliage was most thoroly covered. What becomes of those beetles from the bordeaux-sprayed vines? The facts would seem to indicate that they were repelled and flew to the unsprayed vines or to those sprayed with the molasses-arsenate of lead combination. On the other hand, some observations that make the author reluctant to accept this conclusion are as follows: (1) In all the experiments conducted during the past five seasons, in every vineyard in which a low egg count was secured on the vines sprayed with bordeaux mixture, no matter how severe the infestation previous to spraying, the count on the check plat was lower than in a similarly infested vineyard which had received no spraying; (2) in all vineyards where the spraying was not properly applied, on account of poor apparatus or heavy foliage, or was applied too late in the season, the number of eggs on the check plat was high; (3) in 1914 a vineyard in which no spraying had been done and where the surrounding vineyards had not been sprayed, and one also in which the amount of feeding would not indicate that more beetles were present than in many of the vineyards in which experiments have been conducted, the egg count was likewise high, and was — mark the point — about the same as was secured in the improperly sprayed vineyards.

Weighing everything, we believe the following conclusions are warranted: (1) The bordeaux mixture and arsenate of lead in combination have a decided influence on the unsprayed adjoining vines, either thru killing a considerable number of the insects which might migrate to the sprayed plants or by a repellent action exerted over a considerable space. (2) The egg-counts on the various check

plats minimize the effects of spraying both on the plats sprayed with molasses and poison and those sprayed with bordeaux mixture and poison.

SPRAYING APPARATUS USED IN VINEYARD EXPERIMENTS.

In commercial vineyards in western New York, the vines are planted in rows, and are trained on wire trellises (Plate VI). The rows are rarely closer than eight, and seldom more than ten feet apart. The various types of vineyard sprayers in common use have been built to meet these demands. All spraying can be done automatically; i. e., the nozzles are arranged so that the spray is delivered to the vines without the necessity of a person directing the nozzles as is done in orchard spraying. Generally the operator need only to drive and see that the nozzles are not clogged with foreign material. To avoid this difficulty usually requires little work if the tank was clean when filled, and if the spray materials have been properly strained. With an abundant water supply near the vineyard and proper equipment for filling the tank, it is possible to spray thoroly from eight to ten acres of vines in ten hours.

TYPES OF SPRAYERS.

Sprayers adapted for vineyard work may be classified in several ways: viz., two-wheeled and four-wheeled, engine, compressed air and horse power (Plates VII and VIII), the latter frequently being listed under the caption "geared" or "traction-sprayer." The two-wheeled outfits are better adapted to ordinary vineyard conditions than four-wheeled machines, because of the ease of turning at the ends of the rows. Most vineyardists desire to plant as much ground as possible, leaving only sufficient room at the ends of the rows to turn with the ordinary vineyard machinery and wagons. This space is generally too small for the longer four-wheeled sprayers, altho some of the latter are now being constructed to allow short turning. These four-wheeled outfits have one distinct advantage in that they are easier on the necks of the horses than many of the two-wheeled rigs.

The gasoline engine sprayer is an excellent outfit for vineyards because the required pressure can be maintained independently of the progress of the machine, and this is a very important con-

sideration, especially when the foliage is dense. Fairly high pressures are required for efficient spraying against the grape leaf-hopper. With the "geared" sprayer slow driving usually allows the pressure to decrease. Again, the use of engine sprayers is warranted and is highly desirable on farms where both vineyards and tree fruits are to be sprayed, since the one outfit will serve both purposes. The disadvantage of the engine sprayer where vineyards alone are to be sprayed is the fact that they are more complicated and more likely to get out of order than geared sprayers. This is especially true when we must depend on a poor grade of farm help. The additional first cost and the expense for gasoline and oil should also not be overlooked. Good "geared" sprayers are less liable to get out of order and for ordinary vineyard spraying are more satisfactory in the hands of most grape growers. It is for this reason that fewer coöperative vineyards have been sprayed with gasoline engine sprayers than with "traction" sprayers. All outfits should have pumps that can be readily packed, and the intake should be such as will avoid allowing gritty particles to enter the pump, thus making the packing live longer. In fact, the ideal sprayer for vineyards has not been built at this date, and a grower who is planning to buy an outfit should examine carefully the merits of the various machines, and select the one that most nearly suits his conditions.

PRESSURE.

A pressure of 100 to 150 pounds per square inch has been used in practically all experimental work. This has proved sufficient to produce a driving spray that would coat uniformly both foliage and fruit, at least all that was possible to cover with fixed nozzles. It is doubtful whether higher pressures than those given are necessary. A pressure under 100 pounds will give poor results.

NOZZLES.

The nozzles should deliver a spray coarse enough to thoroly cover the foliage without producing large drops or dripping (Plate IX, fig. 2). The very fine mist-like spray usually recommended is very difficult to force to the under portions of the vines, especially if a light wind is blowing, which usually occurs in regions bordering on the Great Lakes. For this reason most vineyardists are using the

cyclone type of nozzles which are fitted with steel discs (Plate II, fig. 1). These discs can be secured with apertures of different sizes which allow the vineyardist to vary the fineness of the spray according to circumstances. In general, the rule is to use as fine a spray as can be properly applied under the weather conditions at the time of spraying. The attention of growers should be called to the various types of cyclone nozzles which have a sieve in the interior. We have found these excellent for vineyard spraying as they prevent clogging, thus avoiding the stopping of the team in the rows where the horses are apt to break off shoots and fruit while the driver is cleaning the nozzles. These nozzles, however, should be examined a number of times especially at the beginning of spraying, for the sieve may become fouled and thus the pressure in the nozzle will be greatly decreased. As the examinations can be made at the ends of the rows, much loss of time and injury to vines can be avoided.

ARRANGEMENT OF THE NOZZLES.

In commercial vineyards the trellises vary in height, but are seldom higher than five feet or lower than four feet. Spraying to control the grape root-worm necessitates the covering of the upper surfaces of all the foliage with the spray material. Such a standard of thoroness is perhaps never completely attained, but in practice sufficiently thoro spraying consistent with the cost of application can certainly be secured by means of three stationary cyclone nozzles on each side of the sprayer. Thruout this bulletin, where spraying experiments are described, this arrangement of the nozzles is to be assumed unless otherwise specified. The elevation and direction of the nozzles will vary with the height of the vines, the direction of the wind and the arrangement of the vines on the trellis. With the Chautauqua or arm system of training, in which the vines are not more than five feet in height, the lower nozzle should be not over eighteen inches, the middle nozzle about forty-two inches and the upper one between five and six feet above the ground. The upper nozzle should be carried from the sprayer about one foot by means of a pipe, so as to insure thoro treatment of the highest foliage. The proper arrangement and direction to point the nozzles are shown in Plate VIII, fig. 2. All nozzles should be connected in such a manner as to allow independent and quick adjustment in height and direction.

It often becomes necessary to make numerous changes in the same vineyard owing to varying heights of vines, and especially on account of the wind, which frequently necessitates a change in direction of the nozzles on each return trip if the best results are to be secured. *It is always best to spray during a calm* period, but where a large acreage is to be treated it often happens that a part of the spraying must be done under less favorable conditions if the work is to be completed at the proper time.

THE METHODS OF DETERMINING THE RESULTS OF EXPERIMENTS.

LACK OF CORRELATION BETWEEN YIELD AND EFFECTIVENESS OF TREATMENT.

The method of arriving at a true estimate of the efficiency of the various practices of spraying should be one that yields exact results under different conditions of soil, fertilizer and cultivation. These variations in a vineyard do not influence the results of a system of spraying, and therefore the data secured should be free from such disturbing factors. Any method of collecting data that does not avoid such influences is logically wrong. We believe that one of the most uncertain methods in attempts to secure exact data regarding the effects of spraying operations for the control of the grape root-worm is to measure or weigh the crop from sprayed and unsprayed vineyards, because it is very difficult to find a vineyard in which uniformity exists regarding (1) the soil, (2) previous cultivation, (3) fertilization, especially manuring, in the past, (4) present cultivation, and (5) present fertilization. Each of these factors influences the yield to a more or less marked extent. These considerations carry greater weight when we realize that, in order to get exact results, rather large areas must be used as plats, the reason being that the movement of the beetles, especially at the period of dispersion, is apt to cause considerable variation unless the plats are of fair size. When plats of one-half acre or more are used, the variations in the yield of the several plats, *even should there be no variation in infestation by the grape root-worm*, is apt to be very large because of the foregoing factors. This fact is illustrated by the data secured in the Lowell vineyards during 1910, as shown in Table I.

laying in the young fruit just after the blossoms drop, and continue the work until about the middle of July. The second brood of adults do little feeding but go into hibernation soon after emerging.

Externally the injury by the apple curculio appears usually as a deep conical depression with a small scar at the bottom. A section cut thru the center of the pit shows a thin hardened core leading toward the heart of the apple and terminating in a small cavity made by the long beak of the insect. (Fig. 11, B.) Occasionally the area around the puncture becomes elevated so that the pit appears as a crater-like hole at the summit. (Fig. 11, C.) Late oviposition cavities do not cause a deep pit to develop and are about one-eighth of an inch deep and half as wide, with a small opening at the surface. (Fig. 11, A.) Feeding punctures are much smaller.

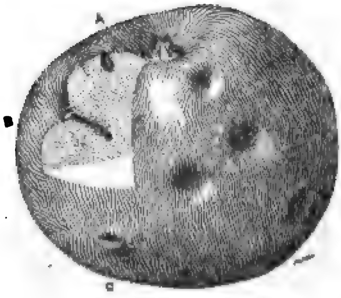

FIG. 11. APPLE CURCULIO.

Control.— The insects thrive only in crowded, uncultivated orchards, so that proper pruning and clean cultivation are the best preventive regulations. In case of an infestation by this insect the wild crab and thorn apples in the vicinity should be cut. The orchard should be cultivated and the infested apples which drop should be fed to stock or raked every few days into the sunlight, which is fatal to both larvæ and pupæ.

14. APPLE-SEED CHALCID.

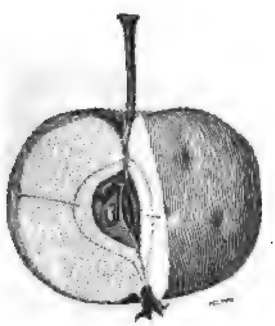

FIG. 12. APPLE-SEED CHALCID.

This insect is of little economic importance, since it affects the seeds more than the flesh of the apple and usually attacks only varieties that bear small fruits, and crab apples. The adults appear in June and deposit eggs in the seeds of the apples.

The only injury visible on the mature fruit is a small black dot often in the center of a shallow depression. A section cut thru black dot will reveal the effect of the ovipositor of the adult insect as a thin brownish line of hardened tissue extending to the core. (Fig. 12.) The seeds which contain maggots are flexible and generally of a pale color.

Control.— Because of the slight degree of injury caused, control measures are not necessary. If preventive measures are desired, a

complete destruction of all apples left under the tree in the fall would be effective, since the insects hibernate in the seeds.

15. San José Scale.

This well-known insect normally lives on the bark, but when abundant many of the larvæ wander to the fruit and leaves, where they settle down and form their scale covering. The young insects begin to hatch sometime between the middle of June and the middle of July, depending on the season, and continue to appear thruout the summer. On the fruit the scales have a tendency to cluster about the calyx and stem. A reddish discoloration of the skin forms about each insect as a circular spot, considerably wider than the scale itself. (Fig. 13.) When the fruit is badly infested the scales overlap and form a grayish scurfy deposit on the surface.

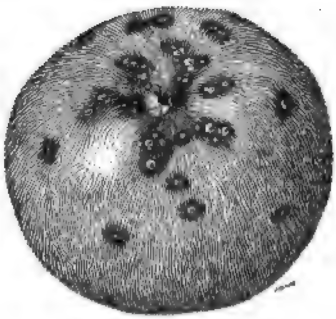

Fig. 13. San José Scale.

Control.— The standard remedy for San José scale is lime-sulphur, used while the trees are dormant or just as the buds show green at the tip.

16. Rosy Apple Aphis.

Altho the injurious work of this insect is confined to a couple of months in the spring, it has a much greater effect on development of the fruit than the green apple aphis which remains on the trees thruout the year. The rosy aphis hatches when the young leaves are beginning to appear at the tips of the buds, usually in the latter part of April, and the last of the winged females leave the trees in the latter part of June. A bad infestation of rosy aphis on a fruit spur, in some way not well understood, often causes all of the apples to set and the result is a cluster of small under-developed fruit. The characteristic cluster apple is compressed from pole to pole, the calyx end is slightly expanded and presents a broad, flattened area, while the portion immediately surrounding the calyx is much wrinkled and puckered. (Fig. 14.)

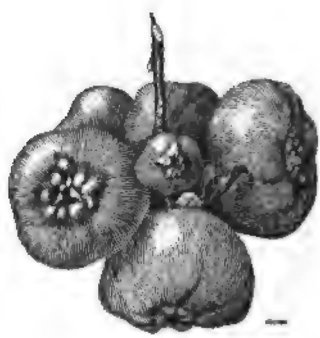

Fig. 14. Rosy Apple Aphis.

Control.— By delaying the dormant spray until the buds show green at the tip the newly-hatched aphids which congregate on them

can be killed by adding nicotine sulphate to lime-sulphur solution at winter strength. Care should be taken to spray all the buds thoroly.

DIRECTIONS FOR SPRAYING APPLES.

Most insects are so irregular in their occurrence that one cannot predict with any degree of certainty what year they are going to appear in injurious numbers. Under ordinary conditions it is advisable that the following spraying schedule be followed entirely each year so as to insure a good crop. Whenever the weather is hot and damp early in the season special precautions against scab are necessary and the time and number of sprays made after the calyx spray should be regulated accordingly. To determine the time of spraying for the second brood of codling moth a burlap band may be tied around a tree trunk to allow the larvæ to pupate under it. During the latter part of July this should be examined every few days, and when empty pupal cases are found within the newly formed cocoons it indicates that the moths have emerged and the time for spraying is at hand.

SPRAYING SCHEDULE FOR APPLE.

Period for Spraying.	Materials in Spray Mixtures.	Insects and Diseases Affected.
DELAYED DORMANT. 	Lime-sulphur. (1–8, winter strength.)	Scale. Blister-mite.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Bud moth. Leaf rollers. Casebearers.
When buds show green at tips.	Nicotine sulphate, $\frac{3}{4}$ pint.	Aphids.
BLOSSOM-PINK. 	Lime-sulphur. (1–40, summer strength.)	Scab.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Green fruit worms. Bud moth. Leaf rollers. Casebearers.
When blossoms show pink.	Nicotine sulphate, 1 pint.	Dark apple red bug.
CALYX 	Lime-sulphur. (1–40, summer strength.)	Scab.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Codling moth. Green fruit worms. Bud moth. Curculios. Lesser apple worm.
When last of petals are falling.	Nicotine sulphate, 1 pint.	Dark and bright apple red bugs.
Later sprays to be determined by weather conditions. Two sprayings often made are (1) two to four weeks after calyx spray, and (2) about the 1st of August, when the second brood of codling moth appears.	Lime-sulphur. (1–40, summer strength.)	Scab.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Codling moth. Curculios. Lesser apple worm. Apple maggot.

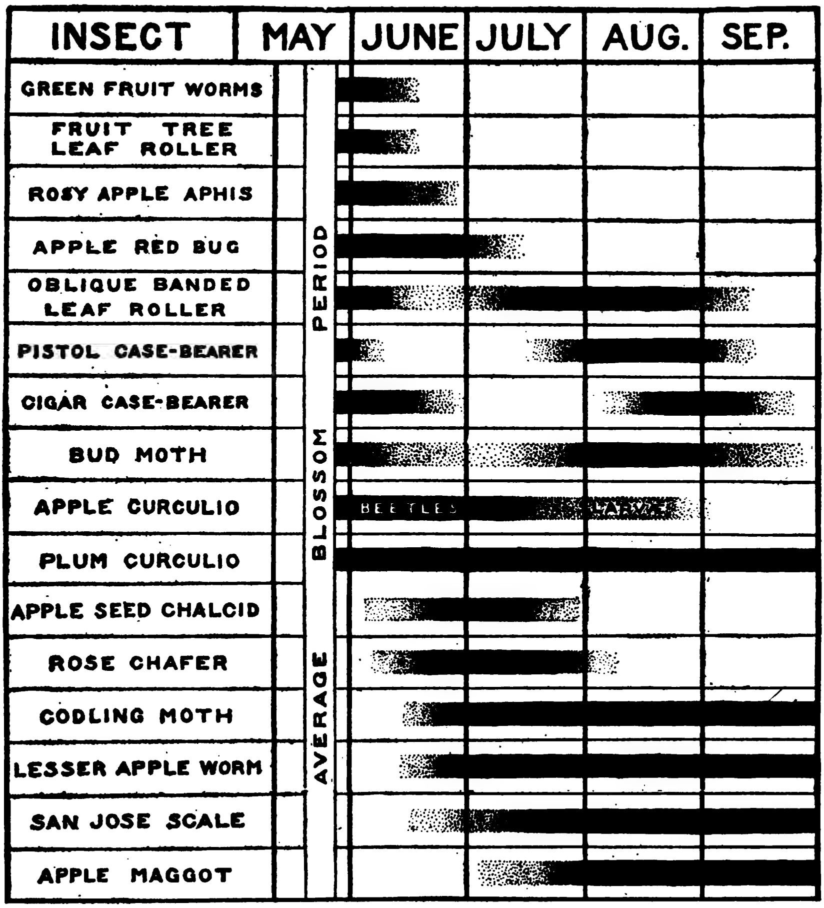

Table I.—Periods During Which the Insects are Actively Injurious to the Fruit But Not Necessarily the Proper Time for Combating Them.

LIME-SULPHUR MIXTURES.

BOILED LIME-SULPHUR WASH.

Lump lime	20 lbs.
Sulphur	15 lbs.
Water	50 gals.

Slake the lime with hot water and make a thin white-wash. Stir in the sulphur and boil one hour. Add water to make the required amount of wash and strain the wash thru a fine strainer into the spraying tank. Application should be made while the wash is warm. Flowers of sulphur, and light and heavy sulphur flour may be used. For the average orchardist this wash will give better results on scale than oil sprays, and the lime-sulphur mixture is especially recommended for the treatment of scale and leaf curl on peaches, the application being made as early as possible in the spring. Sulphur washes of this strength injure foliage and should only be applied to dormant trees.

HOME-MADE CONCENTRATED MIXTURE.

Lime	Pure CaO	36 lbs.
	If 95 per ct. pure	38 lbs.
	If 90 per ct. pure	40 lbs.
Sulphur, high grade, finely divided		80 lbs.
Water		50 gals.

The concentrated mixture is preferred by many fruit growers because of the convenience in handling it as compared with the above wash. The concentrated preparations are free from clogging sediment, may be used cold, are storable, and, therefore, available for use as convenient.

To make the concentrated mixture, place the lime in the container and start it to slaking with a small amount of water and then add the full amount. When the lime is about two-thirds slaked add the sulphur and stir frequently. Cook for three-quarters of an hour after the boiling point is reached. Enough water should be added to make fifty gallons. The mixture should be stored in barrels or other air-tight containers.

COMMERCIAL CONCENTRATED MIXTURE.

Many fruit growers prefer to buy commercial concentrated lime sulphur rather than go to the trouble of preparing it themselves. The concentrated preparations may usually be obtained from local dealers in spraying supplies. The mixtures usually test about 32 degrees Beaumé and are diluted one to eight for winter spray and one to forty for summer treatments of apples.

TESTING AND DILUTING CONCENTRATED LIME-SULPHUR.

The proportions of lime-sulphur and water used to make up the dormant and summer spraying mixtures depend on the strength of the concentrated solution. This can be tested with a Beaumé hydrometer, which is an instrument used for determining the weight and density of liquids. For use with lime-sulphur the hydrometer should be designed for heavy liquids testing as high as 35 degrees. The solutions should be tested when cold, and it is important to keep the hydrometer perfectly clean. After determining the density of the solution it should be diluted for spraying according to the table which follows:

DILUTION TABLE FOR LIME-SULPHUR WASH.

Density of solution in degrees Beaumé.	Dilution for delayed dormant spray. Proportions of lime-sulphur and water to make 100 gallons.		Dilution for summer sprays. Proportions of lime-sulphur and water to make 100 gallons.		Density of solution in degrees Beaumé.	Dilution for delayed dormant spray. Proportions of lime-sulphur and water to make 100 gallons.		Dilution for summer sprays. Proportions of lime-sulphur and water to make 100 gallons.	
	Lime-sulphur.	Water.	Lime-sulphur.	Water.		Lime-sulphur.	Water.	Lime-sulphur.	Water.
	Gals.	*Gals.*	*Gals.*	*Gals.*		*Gals.*	*Gals.*	*Gals.*	*Gals.*
36.....	10	90	2.2	97.8	25....	17	83	3.7	96.3
35.....	10¼	89¾	2.3	97.7	24....	18¼	81¾	4.	96.
34.....	10¾	89¼	2.4	97.6	23....	19½	80½	4.2	95.8
33.....	11¼	88¾	2.5	97.5	22....	20¾	79¼	4.5	95.5
32.....	11¾	88¼	2.6	97.4	21....	22¼	77¾	4.8	95.2
31.....	12¼	87¾	2.7	97.3	20....	23¾	76¼	5.2	94.8
30.....	13	87	2.8	97.2	19....	25½	74½	5.6	94.4
29.....	13½	86½	3.	97.	18....	27	73	6.	94.
28.....	14¼	85¾	3.1	96.9	17....	29	71	6.4	93.6
27.....	15	85	3.3	96.7	16....	31	69	6.8	93.2
26.....	16	84	3.5	96.5	15....	33¼	66¾	7.3	92.7

BENTLEY B. FULTON.

REPORT

OF THE

Department of Horticulture.

U. P. HEDRICK, *Horticulturist.*

ROY D. ANTHONY, *Associate Horticulturist.*

O. M. TAYLOR, *Associate Horticulturist.*

†GEO. H. HOWE, *Assistant Horticulturist.*

J. W. WELLINGTON, *Assistant Horticulturist.*

FRED E. GLADWIN, *Associate Horticulturist.*
(Connected with Grape Culture Investigations.)

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† On leave in war service.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

NEWER VARIETIES OF STRAWBERRIES.*

O. M. TAYLOR.

INTRODUCTION.

This report on strawberries sets forth the results of the tests of the introductions since the issue of Bulletin No. 401. The sixty-one varieties described do not include all that were grown. The standard commercial kinds have fruited each year and have been used as a basis of comparison. Cultural directions are omitted, as this subject is treated in detail in Circular No. 31. All varieties were grown in matted rows, and the selection of soil and the methods followed were as uniform as possible.

Source of varieties.— To avoid the possibility of reporting on plants not true to name the stock was obtained directly from the originator or introducer, if possible, and statements were secured from them in regard to the history of the variety. Past experience has shown that under such apparently favorable circumstances, errors occur and at times reports are received which are at variance with previous statements from the same persons. Plants of over fifty of the varieties came from originators or introducers. Definite statements were secured giving one or both parents of thirty-three varieties, while twenty-eight kinds are chance seedlings of unknown parentage.

Station seedlings.— During the past few years this Station has carried on extensive experiments in the breeding of fruits. The strawberry has not been neglected. Thousands of plants have been under observation. A few of these, after fruiting for several years, were considered worthy of more extended trial. In the spring of 1917 plants of eight kinds that had been named were distributed in different parts of the State for testing under varying soil and climatic conditions. It is not expected that they will all do as well elsewhere as on the Station grounds. After a thoro and extensive test, some of these seedlings may continue to make good records and if so several growers located thruout the State should have

* Reprint of Bulletin No. 447, February, 1918.

plants for sale. This Station has no more plants for distribution of these eight kinds. Full descriptions are included of these seedlings, all of which mature in early or late mid-season.

Plant-makers.— Over-crowding of plants is a common cause of unsatisfactory results. Some kinds like Angola, Frances Willard, Myrtle Murrell, Rewastico and Wildwood produce runners in such numbers that more distance should be given between rows and plants. Other varieties are shy plant-makers and if the ordinary distance is used, the ground is but poorly filled with plants and the yield is low altho the yield per plant may be high. The following twelve kinds have a tendency to produce comparatively few plants:

SHY PLANT PRODUCERS.

Addison	Benancie	*Minnesota No. 1017*
Advance	Friendship	Richmond
Alvin	Hustler	Standpat
Autumn King	J. B.	Todd

Plant-vigor.— Size of plant and sturdiness are relative terms and are influenced by character of soil, food-supply, temperature and rainfall, as well as by the variety itself. Among the strongest-growing kinds may be named Aurora, Edmund Wilson, Ford, *Morgan No. 21* and Wildwood.

Yield.— An unproductive variety is undesirable. Yield is a variable factor influenced by almost every condition of environment. Yet a variety, when all conditions appear ideal, may yield hundreds of quarts of fruit while some other variety under apparently identical conditions will produce thousands of quarts. During the past two years ample rainfall has prevented the usual reduction in yield by drought, but has caused losses at times by keeping foliage and fruit too wet, so it was impossible to remove the heavy yield in good condition. Seven varieties, Benancie, Joe Crampton, Jopp Favorite, Lady Corneille, Myrtle Murrell, Standpat and *Wittlinger No. 1* were uniformly unproductive, while the following nineteen kinds produced fruit in greatest abundance:

VERY PRODUCTIVE VARIETIES.

Allen No. 1	Eureka	Nellis Triumph
Angola	Ford	*Minnesota No. 3*
Athens	Friendship	*Minnesota No. 1017*
Chester	Gibson	Oregon
Collins	*Knight No. 1*	Rewastico
Eldorado	*Morgan No. 21*	Richmond
		Wildwood

Health.— Resistance to disease, when combined with other desirable qualities, is greatly to be desired. It is difficult to determine whether freedom from disease is an inherent quality or is due to lack of conditions which favor the spread of such troubles. Varieties may be healthy one season and show much disease a year later. Several years must elapse and the plants be grown under unfavorable conditions to determine their susceptibility to disease. During the period of this test the following ten varieties showed much injury from leaf-spot:

VARIETIES SUSCEPTIBLE TO LEAF-SPOT.

Alaska	Joe Crampton	Standpat
Charles I	McAlpine	Todd
Friendship	Myrtle Murrell	Warren
		Wildwood

Color of foliage.— Few varieties are characteristic in leaf-color. Rich soil and applications of stable manure or of nitrogenous fertilizers tend to produce a dark green color while lack of nitrogen, as well as conditions of poor drainage, is liable to result in lighter color. The color of foliage appeared lightest in Friendship, McAlpine, Marshall Improved and Myrtle Murrell, the darkest color being represented in Ford, La Bon, Rewastico and Warren.

Sex of plants.— The present-day tendency is to give preference to perfect-flowering or staminate varieties, not because they are more productive or the fruit of higher quality but because it is thus unnecessary to provide other varieties to be used as pollenizers. Only twelve kinds described in this bulletin are imperfect-flowering, while nearly fifty varieties have both stamens and pistils. The twelve varieties referred to are as follows:

FLOWERS IMPERFECT OR PISTILLATE.

Addison	Angola	Kellogg Prize
Alden	Frances Willard	*Knight No. 1*
Allen No. 1	Hustler	*Morgan No. 21*
Alvin	J. B.	Todd

Season of bloom.— Blooming-periods of varieties usually receive little if any attention. It is useless, however, in localities subject to late frosts to attempt to use the varieties that bloom too early. Among the very earliest-blooming sorts are: Alvin, Campbell, Eureka and Wide-awake; sixteen other varieties bloomed early;

four varieties, Autumn King, Hustler, Jopp Favorite and Todd opened their flowers late and the latest of all were Ford and Pearl.

Fruit-stems.— Consideration of fruit-stems might seem at first of no importance, yet their length, thickness and position, have a bearing on the condition of the fruit at harvest time, and the widest variations may be found among the varieties. Conditions of growth, however, may modify the fruit-stems so that these characters are not entirely constant but vary somewhat with the season. Alaska, Alvin, Collins, Ford and *Morgan No. 21* produced very long fruit-stems while those of Charles I, Minnetonka, Premier and Standpat were very short; fruit-stems of Frances Willard, Pearl, Rewastico and Todd were very thick; those of Advance, Autumn King, Collins, Joe Crampton, McAlpine, Myrtle Murrell, Oregon, Standpat, Wide-awake and Wildwood were slender; nineteen varieties produced erect fruit-stems and twenty-three varieties semi-erect to prostrate.

Calyx-characters.— There are usually marked variations in size, position and color of the calyx among varieties, altho some kinds are quite variable in the berries of the same variety. Edmund Wilson, Ford and *Morgan No. 21* developed a calyx of largest size; varieties with a small calyx are represented by Alvin, Argyle, Ashton, Autumn King, Charles I, Eldorado, Standpat and Wide-awake. The position of the calyx is variable; sometimes it is perched on a distinct neck, at other times attached directly to the flat base of the berry, and in some varieties it is sunken deeply in the surface. The calyx of thirty-two varieties was more or less raised, while at least twelve kinds were characterized by the sunken calyx. Attractive appearance of calyx is desirable but here again there are variations, some being uniformly bright, attractive green, others dull, dingy green and at times disease destroys the naturally handsome color. Eleven varieties were noted for the dull, unattractive color of calyx.

Position of seeds.— The position of the seeds in relation to the surface of the berry is usually of but little concern to the strawberry grower, yet it is a character that should not be altogether ignored. They may be characteristically raised above the surface as in the case of Advance and of twenty-four other varieties or the seeds may be deeply sunken in the fleshy surface, as in the case of nineteen kinds. Raised seeds protect the surface from being bruised

and such berries usually ship well, altho in some varieties the numerous, raised seeds give an unattractive appearance, especially with the smaller berries.

Season of ripening.— The time of ripening referred to in this bulletin is the June and early July period and has nothing to do with the "fall-bearing" season, although several varieties are described which characteristically produce their fruit during the fall months. Such varieties were given the same cultural treatment as the other kinds, and this must be borne in mind in interpreting results.

The ripening-season is of great importance. In some localities only the earlier varieties are profitable while in other markets the demand is for late-ripening kinds. In this report the season has been divided into very early, medium early, early mid-season, late mid-season, late and very late. The seasons are overlapping and to make any sort of division, arbitrary dates must be fixed with but scant leeway between the close of one season and the beginning of the next.

VERY EARLY	MEDIUM EARLY	LATE	VERY LATE
Campbell	Advance	Alvin	Abundance
Eureka	Charles I	Autumn King	Ford
Richmond	Eldorado	Hustler	J. B.
	John H. Cook	Kellogg Prize	Joe Crampton
	La Bon	*Knight No. 1*	Jopp Favorite
	Lady Corneille	McAlpine	Pearl
	Marshall Improved	Rewastico	Todd
	Morgan No. 21		Warren
	Minnesota No. 3		Wildwood
	Oregon		
	Premier		
	Wide-awake		

Size of fruit.— Reasonable size is essential either for home use or for commercial purposes. It is dependent partly on the habit of the variety but is influenced largely by the amount of moisture available at ripening time. Berries may be too large as well as too small. Most varieties are intermediate in size. Addison, Ford, Jopp Favorite, Magic Gem, *Morgan No. 21* and Pearl produced fruit of largest size while at the other extreme were Minnetonka, Myrtle Murrell, Standpat and Wildwood. The following varieties retained good size fairly well thruout the season: Arcade, Argyle, Aurora, Charles I, Collins, Edmund Wilson, Frances Willard, Jopp Favorite, Magic Gem, Nellis Triumph, Oregon, Pearl, Warren. Most kinds dropped rapidly in size after the first two pickings.

Shape of fruit.— Shape of fruit is not usually of much concern in varieties of strawberries. There are a few, however, the fruit of which is often malformed or misshapen. Roundish-conic berries usually look better and pack to better advantage than those long or wedge-shaped. Over thirty of the varieties described were conic or roundish-conic; less than half a dozen were roundish; one, the La Bon, was inclined to be oblate; twenty-five kinds were slightly wedge-shaped; five kinds, *Allen No. 1*, Collins, Eureka, John H. Cook and Jopp Favorite were decidedly wedge-shaped; while the long-conic berries were represented by Alaska, Aurora, Frances Willard, Friendship, Greek, Myrtle Murrell, Premier, Richmond and Woodrow.

Color of fruit.— Undesirable color will disqualify any variety. The appearance must be fairly attractive. The berries may be light red, medium red or dark red yet be bright and glossy, giving a handsome appearance. A dull, dingy or faded color is undesirable whether the prevailing color be light or dark. The fruit of fourteen varieties was light red, about the same number medium red, with over a dozen dark red, the darkest of all being Wide-awake. Twenty varieties were dull.

Color of flesh.— The flesh-color depends on the variety and also to some extent on the stage of ripeness. Many berries with light red flesh, whitish at the center, become darker red thruout when fully mature, making it difficult to distinguish those which are characteristically whitish at the center. This character is noted in the description of varieties. Fifteen varieties produced whitish-centered berries, nearly thirty kinds medium to dark red, and twelve kinds light red.

Juiciness of flesh.— The relative amount of juice in the flesh is quite constant. No amount of external moisture will make up for a natural dryness of texture. A dry berry or one lacking in juiciness will continue to be dry, rain or shine. Ten varieties are characterized as very juicy, over thirty as juicy and more than a dozen are lacking in juiciness or are but medium juicy.

Firmness of berry.— Solidity of texture is of great importance. A soft berry is worthless for shipment to any distance no matter how desirable in size, color or flavor, altho this character is not so important for home use. It, however, is always desirable, for lack of firmness almost always results in a " mussy " condition of the

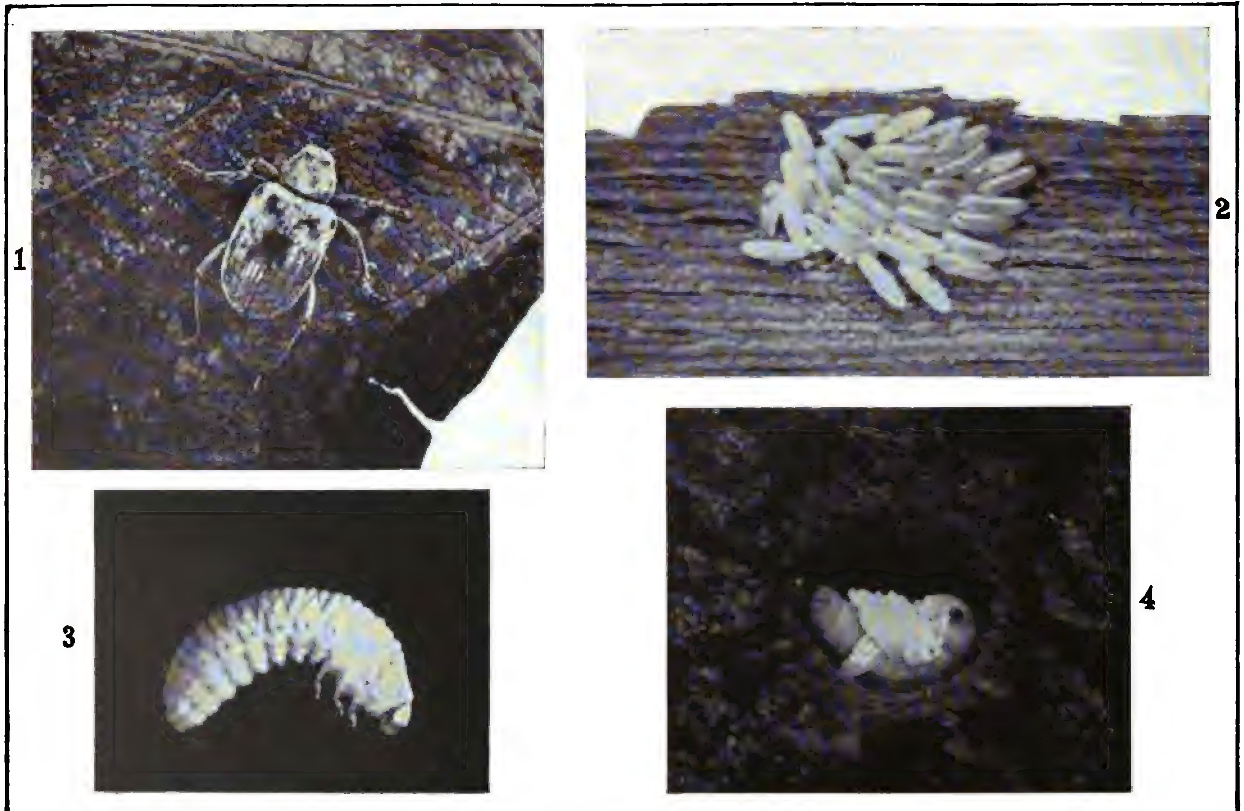

Plate XV.— Life Stages of the Grape Root-worm.
1. Adult × 7; 2, eggs × 8; 3, larva × 5; 4, pupa × 3.

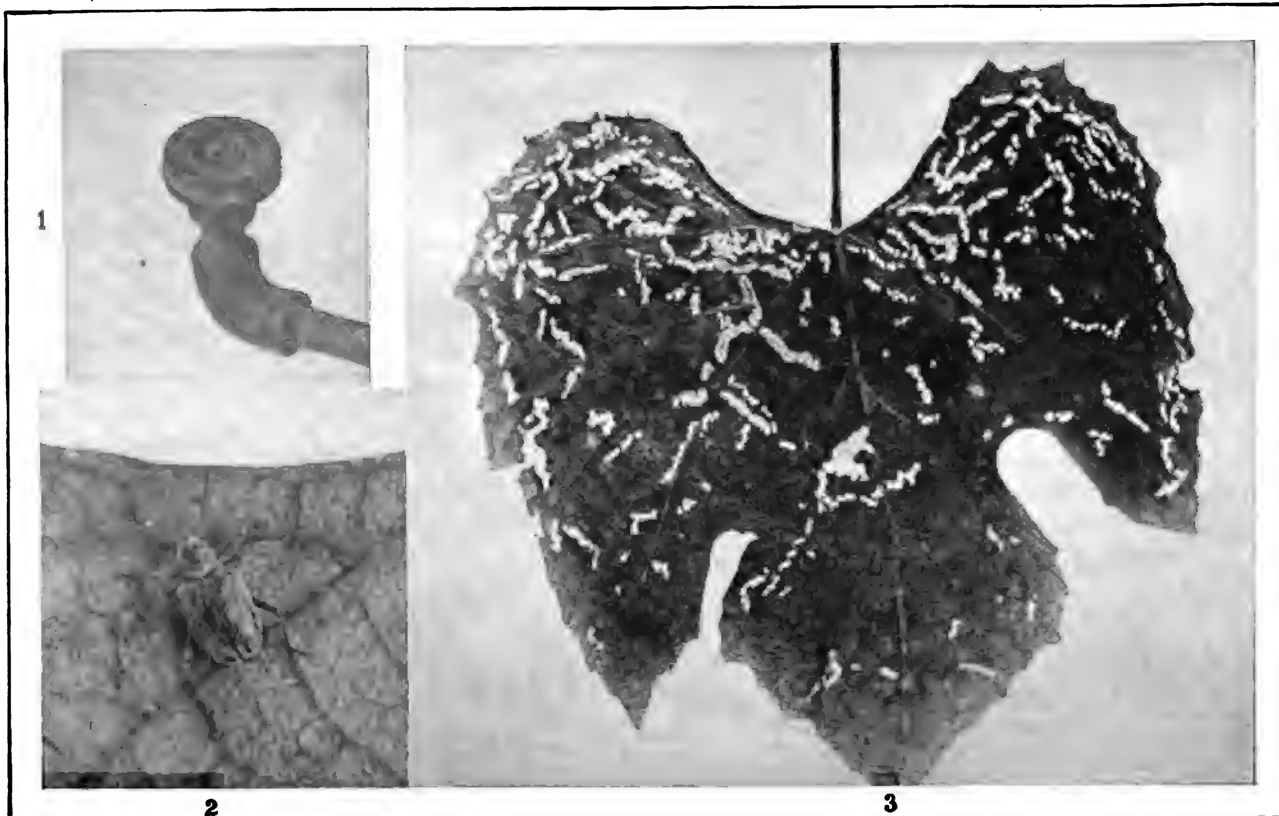

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Plate XVI.— Feeding of Adult Beetles on Grape Leaf. Nozzle.
1. Cyclone type of nozzle; 2, adult on leaf; 3, feeding marks of adults on grape leaf.

Plate XVII.— Effect of Feeding by Grape Root-worm on the Roots of Concord Grape.

Plate XVIII.— Vineyard Injured by Feeding of Grape Root-worm.
Photo taken at Silver Creek, July 23, 1912.

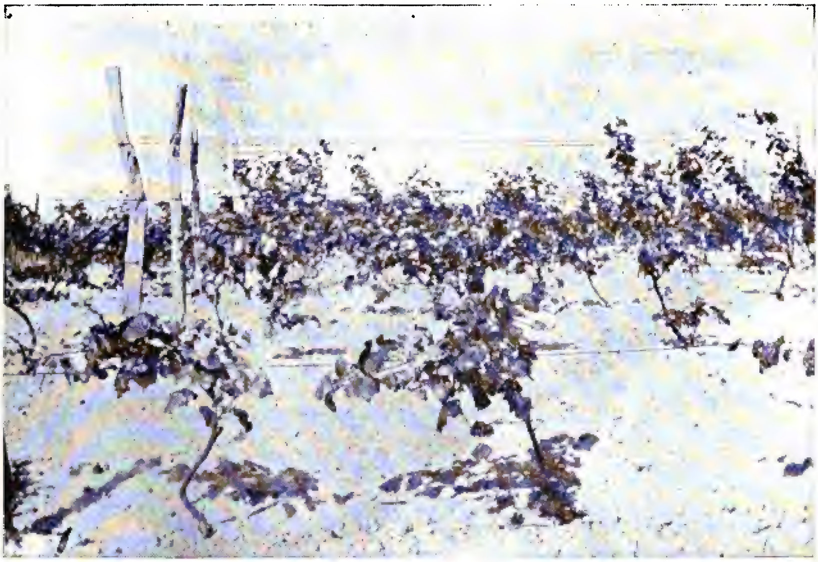

PLATE XIX.— VINES INJURED BY FEEDING OF GRAPE ROOT-WORM.

Fig. 1, photo taken at Ripley, July 1, 1912.
Fig. 2, photo taken at Fredonia, Sept. 15, 1910.

PLATE XX.— VIGOROUS CONCORD VINE WITH FRUIT IN STATION VINEYARD.
Photo taken at Fredonia, Oct., 1909.

PLATE XXI.— TYPES OF HORSEPOWER SPRAYERS.
Fig. 1, Victor sprayer in vineyard of Dr. C. C. Roosa, Silver Creek.
Fig. 2, Brown sprayer in vineyard of S. J. Lowell, Fredonia.

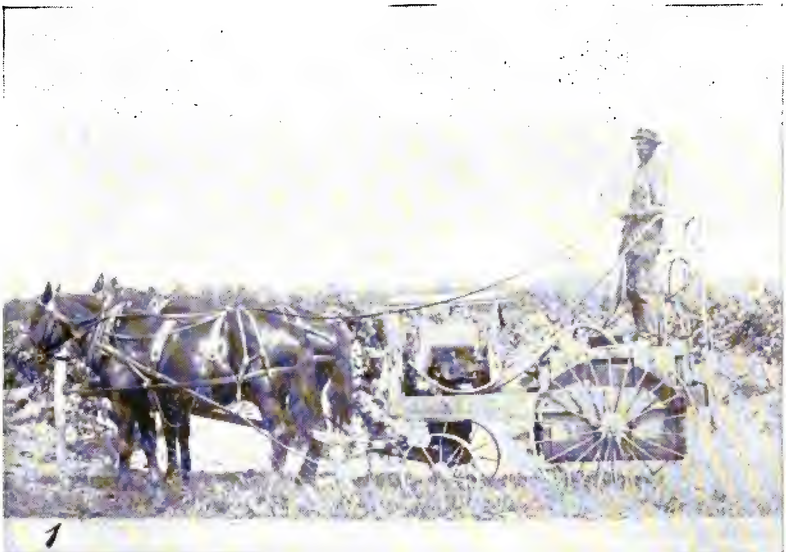

Plate XXII.— Gasoline Engine Sprayer and Proper Arrangement of Nozzles.

Fig. 1, Friend gasoline engine outfit in vineyards of Wright Bros., Westfield.

Fig. 2, Gasoline engine sprayer showing arrangement of nozzles as used for the Chautauqua system of training in Station vineyards at Fredonia.

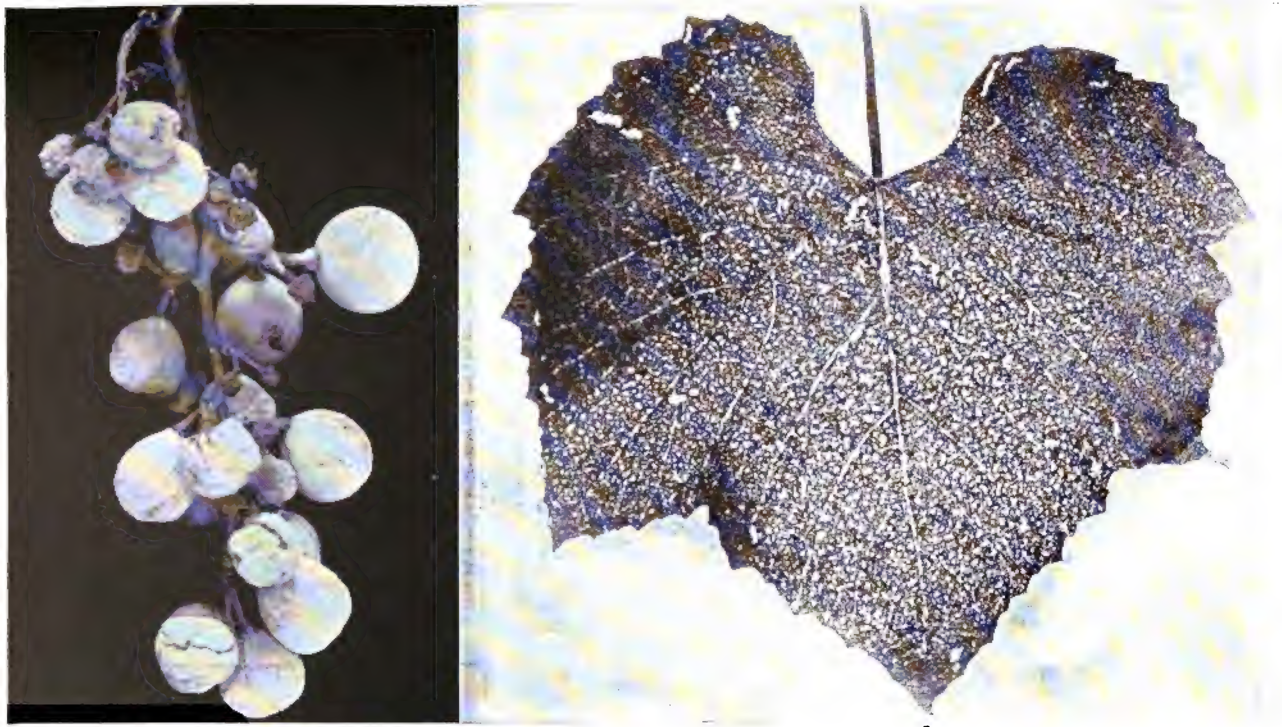

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PLATE XXIII.— INJURY TO CONCORD CLUSTER FROM USE OF ARSENITE OF ZINC.
GRAPE LEAF PROPERLY SPRAYED WITH BORDEAUX MIXTURE AND ARSENATE OF LEAD.

PLATE XXIV.—INJURY TO CONCORD GRAPE FOLIAGE CAUSED BY SPRAYING WITH ARSENITE OF ZINC.

fruit. Among the varieties under discussion, twenty-seven were rated as firm, fifteen as lacking more or less in firmness and the following ten varieties as very firm:

BERRIES VERY FIRM.

Allen No. 1	Magic Gem	*Minnesota No. 1017*
Chester	Minnetonka	Pearl
Greek	*Morgan No. 21*	Wide-awake
		Woodrow

Flavor.— One of the most difficult characters to determine is that of flavor. There is often more or less lack of uniformity in flavor between berries of the same variety, berries ripening in a dry or a wet period, the particular stage of ripeness reached and also a variation in personal likes and dislikes. What is pleasant to one palate may be quite disagreeable to another. There is, however, such a wide variation in flavors among the different varieties that some kind may be found acceptable to almost any palate. Over forty of the varieties may be designated as subacid or slightly sprightly while at the extremes are found seven varieties, Collins, Friendship, Greek, Lady Corneille, *Minnesota No. 1017*, Rewastico and Wide-awake distinctly tart and such varieties as Alaska, Argyle, Chester, Ford, *Knight No. 1*, Myrtle Murrell and *Wittlinger No. 1* among the list of those sweetest. Argyle, Gibson and Magic Gem are among the highest-flavored kinds.

Quality.— The most important rating is that of quality. By quality is meant the sum of all the characters that make the berries desirable to the taste. What varieties may be considered best or poorest in quality? Here again the personal element enters, for standards of judgment differ and what is good in the sight of one person may be moved either forward or backward by some other judge. Three varieties, Argyle, Magic Gem and *Morgan No. 21* were rated very good, over thirty varieties good, eighteen kinds fair and eight varieties distinctly poor.

Promising varieties.— In the determination of what varieties should be recommended for testing, all factors must be considered and each should receive its relative value. It must be remembered that all the varieties fruited on a heavy, cold, clay loam, which is not considered ideal soil for the strawberry. Doubtless on a lighter, warmer soil some of these varieties would have made a better record. All the most promising kinds have their defects as well as their good

points. The following list is therefore only suggestive of those varieties which have made the best showing for one or more years under the local climatic and soil-conditions at this Station. More than half the varieties are in the discard list. The eight seedlings originating at this Station are of course included among those of promise, leaving nine other kinds considered of merit, with eight varieties on the doubtful list, which on account of an unusually fine record along one or more important characters should be further tested despite certain defects.

Desirable Varieties.

Addison	Campbell	Joe (Joe Johnson)
Alden	Eldorado	(?) Kellogg Prize
Angola	(?) Eureka	Magic Gem
Arcade	Ford	*Morgan No. 21*
Argyle	(?) Frances Willard	(?) Minnesota No. 3
Ashton	Gibson	Oregon
Athens	(?) Hustler	Pearl
Aurora	(?) John H. Cook	(?) Warren
		(?) Wide-awake

DESCRIPTION OF VARIETIES.

The following descriptive notes indicate the behavior of the varieties at this Station. The most important characters of plant and fruit have been recorded. The address following the name of each variety gives the source of stock. The history of the variety has been obtained whenever possible from the originator or introducer. Following the description is a paragraph summarizing the comparative value of the variety.

Distribution of varieties.— This Station occasionally distributes seedlings originating here. These are sent only to growers who have opportunity to test them in comparison with other varieties and under such conditions as will make the work profitable to this Station. As a rule, the Station makes its own selection of such growers and there is little need of others to apply. Varieties sent here to be tested are under no circumstances permitted to be sent from the Station grounds.

Abundance.— (H. J. Schild, Ionia, Mich.) A seedling of Indiana originated by H. J. Schild in 1910 and introduced by Flansburgh & Son, Jackson, Mich., and J. T. Lovett, Little Silver, N. J., in 1916.

Plants numerous, of medium vigor, productive, healthy; leaves small, thick, dark green, rugose; flowers perfect, early mid-season, one and one-fourth inches across; petals roundish, six to seven in number; stamens numerous, long; receptacle large,

plump; fruit-stems short, thick, erect, branching; calyx large, much raised, leafy; seeds sunken. Fruit matures very late; intermediate in size, oval to blunt-conic, irregularly furrowed, sometimes wedge-shape, strongly necked, unattractive light red; apex obtuse, indented; flesh light red to the center, medium in juiciness and firmness, sprightly, not high-flavored; quality fair.

Plants somewhat low-growing, with attractive, dark green foliage among which are thickly intermingled the large, showy blooms. A berry not of large size, roughish in general appearance, not attractive in color, characteristically necked, too tart for most palates.

Addison.— (New York Agricultural Experiment Station, Geneva, N. Y.) Flowers of President were fertilized with pollen of Marshall by this Station in 1907; sent out for testing in the spring of 1917.

Plants medium to rather few in number, vigorous, very healthy, productive; leaves large, thick, dark green, rugose; flowers imperfect, open in early mid-season, somewhat small, averaging seven-eighths inch across; petals of medium size, roundish-ovate, six to eight in number; receptacle intermediate in size, roundish to wedge; fruit-stems medium to long, thick, semi-erect to prostrate, branching; calyx rather large, slightly raised, medium green; seeds often variable in position. Fruit matures in mid-season; very large to medium, conic to blunt-wedge, necked, very glossy, attractive medium red; apex obtuse, often indented; flesh red to the center when fully ripe, juicy, medium to firm, mild subacid; good in quality.

Plant-habits unusually good, especially in freedom from leaf-spot; makes more plants than its parent Marshall, yet does not produce runners in abundance; fruit of good size, altho variable, very glossy and usually somewhat necked, very attractive in appearance if not picked too early; greatest defect appears to be the tendency for the surface to bruise unless handled with care; a mild berry of good quality, worthy of trial.

Advance.— (Samuel Cooper, Delevan, N. Y.) A cross between Autumn and Cooper made in 1907 by Mr. Cooper and introduced by him in 1914. An "everbearer."

Plants few, medium in size, vigor and yield, healthy; leaves small, thick, glossy, dark green, smooth; flowers perfect, early, one and one-eighth inches across; petals roundish, five to six in number; stamens variable in number and length; receptacle small; fruit-stems short, slender, semi-erect to prostrate, usually single; calyx of medium size, flat or slightly raised; seeds prominent, much raised. Fruit matures early; medium in size, conic, not furrowed, often slightly necked, glossy, attractive medium red; apex somewhat pointed; flesh medium red thruout, moderately juicy, firm, very mild subacid, not high-flavored; fair in quality.

A poor plant-maker, with fruit characteristic in its glossy, plump surface and raised seeds; one of the best of shippers, attractive in color but disappointing in size and flavor; of the same type as Forward, Onward and Superb.

Alaska.— (T. C. Kevitt, Athenia, N. J.) Resulted from a cross of Climax with Glen Mary by T. C. Kevitt in 1913; not offered to the trade as yet.

Plants numerous, vigorous, medium in yield, injured by leaf-spot; leaves large, thick, dark green, glossy, rugose; flowers perfect, bloom early, one and one-fourth inches across; petals large, roundish, six to eight in number; stamens numerous, long; receptacle large, prominent; fruit-stems very long, medium in thickness, semi-erect to prostrate, branching; calyx large, unattractive in color, somewhat raised; seeds sunken. Fruit matures in mid-season; large to medium, irregular, long-conic to long-wedge, necked, glossy, attractive medium to dark red, often colors unevenly; apex a pointed wedge; flesh rather dark red, variable in color at the center, firm, medium juicy, mild, sweet; fair in quality.

Plants subject to disease, not very productive, producing fruit variable in size, unattractive in shape and color, many berries with a long, whitish or pale-red neck; undesirable.

Alden.— (New York Agricultural Experiment Station, Geneva, N. Y.) A cross between President and Marshall, made by this Station in 1907; introduced for testing in 1917.

Plants medium in number, large, productive, nearly free from leaf-spot; leaves large, thick, dark green, rugose; flowers imperfect, bloom in late mid-season, small, three-fourths inch across; petals small, broadly roundish, usually five in number; receptacle small, conic; fruit-stems long, variable in thickness, prostrate, branching; calyx large, usually flat altho sometimes slightly raised, leafy, with long, broad sepals; seeds variable in position. Fruit matures in mid-season; large, roundish-conic to broad-conic, sometimes slightly necked, variable in color but averaging a bright, glossy, medium red; apex blunt; flesh light red, becoming whitish toward the center, juicy, medium to firm, mild, pleasant flavored; of good quality.

Characters of plant desirable, developing a narrow, matted row, showing a small amount of leaf-spot; fruit of unusually good size, with an attractive calyx, nearly roundish, with a bright, glossy surface which is inclined to bruise easily unless handled with care; flesh somewhat variable in firmness and color, often whitish at the center, pleasant flavored; should be tested further.

Allen No. 1.— (W. F. Allen, Salisbury, Md.) A variety of unknown parentage found by Mr. Earnest Hurley, Salisbury, Md., about 1912, growing and fruiting in the woods near his house. The entire stock was purchased by Mr. Allen; not yet introduced.

Plants numerous, vigorous, healthy, very productive; leaves large, thick, dark green, rugose, glossy; flowers imperfect, bloom in late mid-season, less than one inch across; petals medium in size, often crinkly, roundish-ovate, five to seven in number; receptacle medium in size; fruit-stems long, thick, erect, branching; calyx medium in size, flattened, dull green; seeds sunken. Fruit matures rather late; above medium in size, irregular wedge, furrowed, slightly necked, dull, unattractive dark red; apex blunt, indented; flesh dark red, very firm, juicy, mild, not high-flavored; inferior in quality.

An imperfect-flowering variety with good plant-habits but deficient in color of fruit and lacking in flavor and quality.

Alvin.— (Louis Hubach, Judsonia, Ark.) A seedling, secured by Mr. Hubach by crossing Klondike with Climax in 1908; introduced by him in 1912.

Plants few in number, intermediate in size and vigor, healthy, productive; leaves large, of medium thickness, dark green, smooth; flowers imperfect, bloom very early, one inch across; petals roundish, overlapping, seven to eight in number; receptacle medium in size, conic; fruit-stems very long, of medium thickness, erect, becoming prostrate with the weight of fruit, branching; calyx small, depressed often discolored; seeds sunken. Fruit matures in mid-season; large, dropping in size rapidly as the season advances, wedge to roundish-conic, the largest berries often double, dull, unattractive light red; apex obtuse; flesh variable in color, very juicy, medium in firmness, sprightly, unpleasant flavor; poor in quality.

Characteristic at blooming-time with the long, upright, much-branched blossom-stalks; a light red berry, variable in size, shipping poorly and low in quality.

Angola.— (New York Agricultural Experiment Station, Geneva, N. Y.) In 1907 this Station crossed President with Marshall. One of the resulting seedlings was named Angola and in 1917 plants were sent out for testing.

Plants very numerous, vigorous, healthy, very productive; leaves intermediate in size, thickness and color, somewhat rugose; flowers imperfect, blossom in late mid-season, one inch across; petals of medium size, roundish, five to eight in number; fruit-stems long, thick, prostrate, single; calyx of medium size, flat; seeds somewhat raised. Fruit matures in mid-season; very large to medium, the largest berries with roughish surface, roundish-conic to blunt-wedge, glossy, attractive, medium to light red; apex very obtuse; flesh light red, sometimes whitish toward the center, very juicy, intermediate in firmness, slightly sprightly; good in quality.

An imperfect-flowering variety, producing plants in great numbers; berries among the largest of the Station seedlings, retain size well during the season, unusually attractive in their bright, glossy, red color; must be handled with care to avoid bruising the surface; worthy of test.

Arcade.— (New York Agricultural Experiment Station, Geneva, N. Y.) Flowers of President were fertilized by this Station in 1907 with pollen from Marshall. Among the resulting seedlings, one of promise was named Arcade and was distributed for testing in 1917.

Plants medium in number, vigorous, productive, variable in health; leaves large, thick, medium green, rugose; flowers perfect, open in early mid-season, one and one-fourth inches across; petals large, broadly roundish, six to eight in number; stamens numerous, above medium in length; receptacle intermediate in size, conic; fruit-stems long, thick, semi-erect, branching; calyx medium in size, flat or slightly raised, with long, rather broad sepals; seeds even or slightly raised. Fruit matures in mid-season; large, retains size well during the season, conic to slightly wedge, often necked, attractive, glossy, medium red; apex somewhat pointed; flesh light red, sometimes whitish towards the center, very juicy, rather firm, pleasant flavored, somewhat sprightly; of good quality.

Plants have been under test for several years and have been uniformly healthy except in 1917 when they were injured by leaf-spot; surface firmer and making a better shipper than some of the other seedlings of this Station; worthy of test on account of attractiveness in size, shape, color and desirable flesh-characters.

Argyle.— (New York Agricultural Experiment Station, Geneva, N. Y.) A seedling of President crossed with Marshall, in 1907 by this Station; introduced for testing in 1917.

Plants intermediate in number, vigorous, healthy, productive; leaves of medium size, thick, dark green, glossy, rugose; flowers perfect, bloom in early mid-season, one and one-eighth inches across; petals of medium size, roundish-ovate, five to eight in number; stamens variable in number, short; receptacle medium in size, roundish-conic; fruit-stems medium to long, intermediate in thickness, semi-erect to prostrate, single; calyx small, depressed or flattened; seeds even or slightly raised. Fruit matures in mid-season; above medium to very large, roundish-conic, the largest berries irregularly furrowed, glossy, attractive medium to dark red; apex obtuse; flesh light red, sometimes whitish towards the center, juicy, firm, mild, sweet, high-flavored; very good for a mild berry.

A perfect-flowering, mid-season variety with good plant-habits; berries of largest size, good flavor and quality, ship well, must be picked with care to secure uniform color; worthy of test for a mild berry of high quality.

Ashton.— (New York Agricultural Experiment Station, Geneva, N. Y.) This Station, in 1907 made a cross between President and Marshall. One of the most promising seedlings was named Ashton and was sent out for testing in the spring of 1917.

Plants intermediate in number, vigorous, healthy, productive; leaves large, thick, very glossy, dark green, nearly smooth; flowers perfect, appear in early mid-season, one and three-eighths inches across; petals large, roundish-ovate, five to seven in number; stamens numerous, above medium in length; receptacle of medium size, conic; fruit-stems short to medium, thick, semi-erect to erect, single; calyx small, depressed; seeds prominent, raised. Fruit matures in early mid-season; large, roundish-conic, surface of the largest berries irregularly furrowed, glossy, attractive medium to dark red; apex obtuse; flesh variable in color, juicy, firm, somewhat sprightly; good in quality.

Resembles Argyle closely in size of fruit, color and shape but the calyx is slightly more sunken, the seeds more raised and the flesh more sprightly; on the Station soil, held its own with the best commercial varieties.

Athens.— (New York Agricultural Experiment Station, Geneva, N. Y.) A cross between President and Marshall, made by this Station in 1907; introduced for testing in the spring of 1917.

Plants medium in number, vigorous, usually healthy, very productive; leaves intermediate in size, thick, dark green, rugose; flowers perfect, bloom in early mid-season, one inch across; petals below medium in size, roundish; fruit-stems medium to long, thick, semi-erect, branching; calyx medium in size, variable in position,

with short, broad sepals; seeds usually sunken altho variable. Fruit matures in mid-season; large, dropping in size as the season advances, irregular-wedge to irregular-conic, the largest berries furrowed, usually necked, bright red to darker red depending on stage of maturity, glossy, attractive; apex variable in shape; flesh not uniform in color, very juicy, firm, pleasant flavored, sprightly; good in quality.

Plants very desirable in habit except for an attack during one year of leaf-spot; unusually good in size, somewhat variable in color depending on stage of ripeness; a sprightly berry, pleasant flavored, dropping in size as the season advances; the bright red color is most attractive both in the fresh fruit and in the canned product; should be tested further.

Aurora.— (New York Agricultural Experiment Station, Geneva, N. Y.) A pure seedling of Prolific started in 1907 by this Station and introduced as worthy of test in the spring of 1917.

Plants numerous, very vigorous, somewhat injured by leaf-spot under unfavorable conditions, medium in yield; leaves large, of medium thickness, dark green, nearly smooth; flowers perfect, bloom in late mid-season, one inch across; petals of medium size, broadly ovate, six to eight in number; stamens medium in number, short; receptacle intermediate in size, roundish to wedge; fruit-stems rather short, thick, semi-erect, branching; calyx large, flat, leafy, attractive green; seeds usually sunken. Fruit matures in late mid-season; large, retains size well during the season, symmetrical, long-conic to long-wedge, usually not necked, glossy, attractive medium red, colors evenly; apex pointed; flesh well colored, juicy, firm, agreeably sprightly; good in quality.

Habits of plant desirable except that under unfavorable conditions the foliage may be injured by leaf-spot; the latest blooming of the eight Station seedlings described in this bulletin; a bright red, long-conic berry usually with pointed apex, shipping well; flesh sprightly and of good flavor; should receive a more extended trial.

Autumn King.— (E. W. Townsend, Salisbury, Md.) Secured in 1911 by Mr. Townsend by crossing Autumn with Chesapeake and introduced by him in 1914; an "everbearer."

Plants very few, medium in vigor and yield, healthy; leaves small, thick, dark green, rugose; flowers perfect, small, usually less than one inch across, bloom late; petals roundish, six to seven in number; stamens numerous, short; receptacle of medium size, blunt-conic; fruit-stems short, slender, prostrate, single; calyx small, raised; seeds usually raised, prominent. Fruit matures late; medium in size, conic, sometimes faintly and irregularly furrowed, necked, variable in color, glossy; flesh red thruout, medium juicy, firm, mild subacid, not high flavor; inferior in quality.

Almost no runners developed from the plants. The fruit, as compared with June-fruiting varieties was easily surpassed both in size and quality.

Benancie.— (Louis Hubach, Judsonia, Ark.) A cross of H & H with Climax made by Mr. Hubach in 1908; introduced by him in the spring of 1912.

Plants few in number, intermediate in size and vigor, healthy, unproductive; leaves variable in size, thick, medium green, rugose; flowers perfect, bloom early, one and one-eighth inches across; petals roundish, six to eight in number; stamens medium in number; receptacle of average size, roundish; fruit-stems rather short, thick, semi-erect, single; calyx large, flattened, leafy; seeds prominent, raised. Fruit matures in mid-season; medium in size, wedge to blunt-conic, glossy, attractive dark red; apex variable in shape; flesh dark red thruout, juicy, firm, decidedly sprightly; of good quality.

An early-blooming variety producing but few plants which are unproductive; a dark red, tart berry, somewhat seedy in appearance, inferior in size, an unusually good shipper, surpassed in value by other varieties of its season.

Campbell.— (W. B. Kille, Swedesboro, N. J.) A seedling of unknown parentage, originating with James Campbell, Newport, N. J., in 1910; introduced by Mr. Kille in 1916.

Plants medium in number and vigor, healthy, productive; leaves intermediate in size and thickness, dark green, rugose; flowers perfect, open very early, one and

one-fourth inches across; petals of medium size, six to eight in number; stamens numerous, long; receptacle prominent, roundish; fruit-stems short, thick, prostrate, double; calyx medium in size, flat or slightly raised; seeds sunken. Fruit matures very early; of good size in the first two pickings, later dropping rapidly in size, wedge to conic, the smaller berries slightly necked, variable in color and glossiness; apex a blunt-wedge; flesh light red, variable color at the center, juicy, firm, subacid or pleasantly sprightly; good when fully ripe.

The earliest to ripen in 1917; one of the most productive of the early varieties; plant-habits good; two heavy picks before Dunlap ripens, after which the size is disappointing and color becomes dingy; pleasant flavor and high quality most pronounced in the fully ripe fruit, the lighter berries whitish at the center; flowers open too early in localities subject to frosts, the earliest of the sixty-one varieties described in this bulletin; in spite of its defects, worthy of test on account of earliness and high quality.

Charles I.— (O. A. D. Baldwin, Bridgman, Mich.) A chance seedling found in the woods about 1905 by George Hann, Bridgman, Mich.; introduced by Mr. Baldwin in 1911.

Plants numerous, medium in vigor, severely attacked by leaf-spot, productive; leaves small, thin, medium green, rugose; flowers perfect, early, one inch across; petals medium in size, roundish-oval, five to eight in number; stamens numerous, long; receptacle small; fruit-stems very short, thick, much prostrate; calyx small, flat, dingy green; seeds sunken. Fruit matures medium early; large, retains size well during the season, very blunt-conic, characteristically light red, dull, unattractive; apex much obtuse; flesh whitish toward the center, juicy, lacking in firmness, mild, not high-flavored; inferior in quality.

Plants altho productive are subject to disease; berries of good size and shape but are too soft for a desirable shipper, unattractive in color and lacking in flesh-characters.

Chester.— (W. S. Todd, Greenwood, Del.) A chance seedling of unknown parentage found in a yard in Chester, Pa., in 1912. Plants were sold locally in 1915.

Plants intermediate in number and vigor, healthy, very productive; leaves small, of medium thickness, dark green, rugose, glossy; flowers perfect, bloom in late mid-season, one and one-eighth inches across; petals large, roundish, five to seven in number; stamens numerous, variable in length; receptacle of medium size, roundish-conic to wedge; fruit-stems intermediate in length, thick, erect, branching; calyx large, leafy, flat or depressed, attractive green; seeds raised. Fruit matures in mid-season; large, irregular roundish to almost oblate, much furrowed, medium to dark red, not very attractive; apex indented, green-tipped and seedy; flesh rather dark red, medium juicy, very firm, often hollow at the core, sweet, mild; good in quality.

A very productive, healthy variety, fruit of which is fig-like in type, of desirable size and quality as well as one of the best of shippers but the surface is strongly furrowed and the apex too often mal-formed and seedy to make a pleasing appearance.

Collins.— (C. E. Whitten, Bridgman, Mich.) Thought to be a cross between Beder Wood and Pocomoke, the seed of which was sown in 1910 by C. H. Collins, Bridgman, Mich.; introduced in the spring of 1915 by Mr. Whitten.

Plants numerous, vigorous, nearly free from leaf-spot, very productive; leaves large, thin, dark green, smooth; flowers perfect, appear in late mid-season, one inch or less across; petals small, obovate, five to seven in number; stamens numerous, long; receptacle small; fruit-stems very long, slender, prostrate, single; calyx of medium size, tinged red, strongly raised, with sepals much reflexed; seeds variable in position. Fruit matures in mid-season; large, retains size well during the season, furrowed, wedge-shape, strongly necked, attractive, glossy, medium to light red, coloring somewhat unevenly; apex pointed, often green-tipped; flesh medium red, juicy, firm, almost tart, with an unpleasant flavor; fair in quality.

Plant-habits unusually good, especially in yield; a mid-season variety, a splendid shipper, unusually attractive in size, shape and color but unfortunately on the soil at this Station the flavor is decidedly tart and the quality not of the highest.

Dr. Burrill.— (R. M. Kellogg Co., Three Rivers, Mich.) Blossoms of Crescent were fertilized with pollen from flowers of Dunlap by J. A. Reasoner, Urbana, Ills. One of the resulting seedlings was named Dr. Burrill; introduced by the Kellogg Co. in 1916.

Plants numerous, intermediate in vigor, healthy, productive; leaves of medium size, thickness and color, rugose, glossy; flowers perfect, open in early mid-season, one and one-eighth inches across; petals small, roundish, five to eight in number; stamens medium in number and length; receptacle small, conical; fruit-stems intermediate in length and thickness, semi-erect, branching; calyx of medium size, distinctly raised, with reflexed sepals, attractive green; seeds sunken. Fruit matures in late mid-season; large, regular, conical to slightly wedge, strongly necked, medium to dark red, glossy; apex pointed; flesh medium red thruout, variable in juiciness and flavor, firm, averaging subacid; fair to good in quality.

A perfect-blooming variety of good plant-habits, ripening in late mid-season; berries excellent in size, color and shape, type of Dunlap, but milder and disappointing in both flavor and quality.

Edmund Wilson.— (J. T. Lovett, Little Silver, N. J.) One of Dr. Van Fleet's seedlings of unknown parentage; originated in 1907; introduced by Mr. Lovett in 1913.

Plants numerous, very vigorous, healthy, productive; leaves characteristically large and dark green, medium in thickness, rugose; flowers perfect, bloom early, very large, often nearly two inches across; petals roundish, crinkly, five to eight in number; stamens intermediate in number and length; receptacle large, prominent; fruit-stems rather short, thick, semi-erect to prostrate, single; calyx of largest size, leafy, depressed; seeds usually sunken. Fruit matures in mid-season; large, retains size well to close of season, irregular-conic, broad at the base, variable in glossiness, dark red; apex obtuse; flesh dark red thruout, medium juicy, firm, mild subacid; fair in quality.

Plants characteristic in their large leaves, dark green color and in the pleasing appearance of the unusually large blossoms thickly interspersed among the foliage; altho the fruit is of good size, the color is often dull, the calyx detracts from the appearance and the flesh is inferior in flavor and quality.

Eldorado.— (King Bros. Nursery, Dansville, N. Y.) Plants of this variety were sent to the Station for testing in the spring of 1916 by the King Brothers. Its origin seems to be obscure; said to have been introduced from Kansas.

Plants numerous, vigorous, healthy, very productive; leaves above medium in size and thickness, smooth, very glossy, medium green; flowers semi-perfect to perfect, bloom early, one inch across; petals small, roundish, six to eight in number; stamens medium to numerous, long; receptacle large, prominent; fruit-stems of medium length, variable in thickness, prostrate, branching; calyx small, flat, attractive green; seed variable altho mostly raised. Fruit matures medium early; large, irregular shape varying from roundish to very blunt-conic or wedge, broad at the base, medium to light red, somewhat glossy; apex very obtuse, indented; flesh whitish toward the center, juicy, firm, mild subacid, pleasant flavor; good in quality.

An early-blooming variety of excellent plant-habits, very productive for an early-ripening kind; berries of good size which is retained thruout the season better than the attractiveness of color, milder and sweeter than Dunlap; altho the color is rather dull toward the close of the season, the earlier pickings are much above the average and the variety is therefore considered worthy of further test.

Eureka.— (Louis Hubach, Judsonia, Ark.) Originated in 1910 with Mr. Hubach by crossing one of his unnamed seedlings with Klondike; introduced by him in 1912.

Plants intermediate in number, size and vigor, healthy, very productive; leaves small, thick, medium to dark green, nearly smooth; flowers perfect, bloom very early, one and one-half inches across; petals broad-oval, seven to eight in number; stamens numerous, long; fruit-stems short, thick, erect, branching; receptacle medium in size, blunt; calyx intermediate in size, depressed; seeds sunken. Fruit matures very early;

large to medium, slightly furrowed, wedge-shape, glossy, dark red; apex obtuse; flesh dark red to the center, juicy, firm, often hollow at the core, sprightly; good in quality.

May possibly have value on account of extreme earliness. The berries give indications of considerable value but unfortunately the crop was seriously injured by frost and drought so that the berries showed defects from such causes; requires further testing to determine its value.

Ford.— (E. W. Townsend, Salisbury, Md.) A chance seedling found growing wild by Mr. Granvill Brewington about 1913 in Wicomico County, Md.; introduced by Mr. Townsend in 1916.

Plants numerous, extremely vigorous, healthy, very productive; leaves of largest size, very thick, markedly dark green, rugose; flowers semi-perfect to perfect, bloom very late, one and one-half inches across; petals large, roundish, six to seven in number; stamens variable in number and length; receptacle of medium size; fruit-stems very long, thick, erect, branching into many long pedicels; calyx unusually large, flat, very leafy, attractive green, with long and broad sepals; seeds variable in position. Fruit matures very late; of largest size, regular, blunt-wedge to blunt-conic, attractive, glossy, medium to dark red, coloring somewhat unevenly; apex obtuse; flesh red thruout, unusually juicy, firm, mild, sweet; of good quality.

One of the best of the late varieties. A characteristic variety in its large, dark green leaves, large blossoms, long, erect and branching fruit-stems, size of calyx, as well as in the size and juiciness of the fruit; color somewhat variable yet attractive; surface bruises unless handled with care; retains size well thruout the season; the lateness of bloom is an asset in localities subject to late frosts; worthy of extended trial.

Forward.— (Samuel Cooper, Delevan, N. Y.) A seedling of Autumn crossed with Cooper in 1907 by Mr. Cooper; introduced by him in 1914. An "everbearer."

This variety is so similar in both plant- and fruit-habits to Advance that one description will answer for both varieties. See Advance for description.

Frances Willard.— (M. Crawford Company, Cuyahoga Falls, Ohio.) Seeds from an unnamed seedling were sown in 1910 by D. J. Miller, Millersburg, Ohio. One of the resulting plants was named Frances Willard and in 1914 was introduced by the Crawford Company.

Plants very numerous, vigorous, healthy, very productive; leaves unusually large, thick, dark green, rugose; flowers imperfect, open in mid-season, one inch across; petals broad-oval, five to seven in number; receptacle large, conic; fruit-stems rather long, very thick, semi-erect to prostrate, usually single; calyx medium to large, strongly raised; seeds variable in position. Fruit matures in late mid-season; large, retains size well during the season, long-conic to long-wedge, much necked, medium attractive, slightly glossy, rather light red; apex pointed; flesh light red to the center, medium juicy, firm, mild subacid; fair to probably good.

Plant-habits unusually good; fruit characterized by being strongly necked, long shape, excellent size, attractive externally but unfortunately the flesh-characters are disappointing; not very juicy, very mild, not high flavor; would make a good show berry — but would compare unfavorably with high-quality berries such as Marshall.

Friendship.— (J. F. Nickerson, Chatham, Mass.) Said to be a seedling of the Corsican found by Mr. Nickerson; not yet introduced.

Plants rather few, intermediate in vigor, injured by leaf-spot, very productive; leaves large, thin, light green, nearly smooth; flowers perfect, one inch or less across, open in early mid-season; petals very small, often greenish-white, broadly roundish, seven to nine in number; stamens numerous, long; fruit-stems short, thick, prostrate, single; receptacle large, roundish; calyx of medium size, raised, with long and narrow sepals; seeds slightly sunken. Fruit matures in mid-season; variable in size, long-wedge to long-conic, strongly necked, medium to light red, dull; apex pointed, flesh medium red to the center, juicy, moderately firm, tart, not pleasant flavor; poor in quality.

Altho very productive, the plants appear subject to disease and the fruit is disappointing in size and flesh-characters.

Gibson.— (David Knight & Son, Sawyer, Mich.) Thought by some to have come from Berrien County, Mich., but the origin and parentage appears to be obscure; catalogued in 1911 by Knight & Son. This variety is said to be distinct from the Gibson of New York. It is considered by some very similar to Parson Beauty and Pocomoke.

Plants rather numerous, of medium vigor, with but a trace of leaf-spot, very productive; leaves intermediate in size and thickness, dark green, slightly rugose; flowers perfect, large, nearly one and one-half inches across, crinkly, bloom early; petals large, broadly roundish, seven to nine in number; stamens numerous, long; fruit-stems of medium length, thick, semi-erect, single; receptacle large, roundish; calyx rather large, raised, leafy; seeds slightly sunken. Fruit matures in mid-season; above medium in size, blunt-wedge to conic, necked, attractive medium to light red; apex often pointed; flesh light red, juicy, firm, pleasantly sprightly, high-flavored; of good quality.

Plant-habits unusually good; a mid-season variety, with fruit of good color and fairly good size, a fine shipper, pleasing in its sprightliness, altho at the last it loses somewhat both in color and size; worthy of test for a commercial berry.

Greek.— (L. J. Farmer, Pulaski, N. Y.) Said to have originated with Sylvester Marshall, Athens, Ohio, in 1912; introduced in the spring of 1916 by Mr. Farmer.

Plants intermediate in number and vigor, healthy, productive; leaves of medium size, thickness and color, rugose; blossoms perfect, appear in early mid-season, one and one-eighth inches across; petals roundish-ovate, five to eight in number; stamens numerous, intermediate in length; receptacle of average size, roundish; fruit-stems above medium in length, semi-erect, branching into long pedicels; calyx large, distinctly raised and with long, reflexed sepals, tinged red; seeds raised. Fruit matures in mid-season; above medium in size, long-conic, almost oblong, strongly necked, attractive, glossy, medium red; apex pointed; flesh red to the center, juicy, very firm, tart or sprightly; fair in quality.

One of the best shippers of all the varieties and of handsome color; shape objectionable, and flesh too tart for most palates.

Hustler.— (W. F. Allen, Salisbury, Md.) A seedling of unknown parentage found in 1910 by R. P. Lovett, Fallsington, Pa.; introduced in the spring of 1915 by Mr. Allen.

Plants very few in number, of medium vigor, healthy, productive if planted closely; leaves medium to large, thin, intermediate in color; flowers imperfect, bloom late, one inch or more in diameter; petals of medium size, roundish, six to seven in number; pistils tinged red; receptacle large, prominent; fruit-stems short, thick, prostrate, branching; calyx large, raised, leafy; seeds raised. Fruit matures in mid-season; large, dropping in size as the season advances, roundish-conic, necked, attractive, medium red; apex very obtuse; flesh red thruout, medium in juiciness and firmness, pleasantly sprightly; good in quality.

An imperfect-flowering, mid-season variety developing but few runners and must be planted closely to secure a large yield; berries altho dropping in size as the season advances, are attractive in color, a good shipper, the raised seeds on the smaller berries detracting somewhat from appearance; distinctly necked; may have value to those who prefer a sprightly berry.

J. B.— (Louis Hubach, Judsonia, Ark.) A cross between Nettie and Aroma originating with Mr. Hubach in 1909; not introduced.

Plants few in number, medium in vigor, healthy, productive; leaves intermediate in size, thick, dark green, rugose; flowers imperfect, bloom early, small, less than one inch across; petals roundish, seven to nine in number; fruit-stems of medium length and thickness, erect, branching; receptacle very large, long-conic; calyx medium in size, flat to raised; seeds variable in position. Fruit matures very late; above medium in size, irregular-wedge to conic, furrowed, usually necked, attractive medium red; apex pointed; flesh red to the center, juicy, medium firm, pleasantly sprightly; good to very good in quality.

A berry of fairly good size, slightly dull in general appearance especially in the later pickings, but with desirable flesh-characters. Not equal to the best varieties of its season.

John H. Cook.— (J. T. Lovett, Little Silver, N. J.) One of Dr. Van Fleet's seedlings of unknown parentage grown by him in 1908; introduced by Mr. Lovett in 1915.

Not enough plants for a satisfactory test. So far as could be determined, the variety is perfect-flowering, blooming in mid-season, maturing its fruit medium early. The small amount of fruit available for test was of large size, attractive, glossy, dark red, wedge-shape, mild, pleasant subacid, and good quality. The variety may possess considerable value but it requires further testing to determine its standing.

Joe Johnson.— (E. W. Townsend, Salisbury, Md.) As fruited at this Station, there appears to be but minor differences if any from the Big Joe or Joe — fully described in previous bulletins as a perfect-flowering, late or late mid-season variety having many qualities to commend it, especially large size of fruit, attractive color and desirable flavor and quality. Reports from other states also indicate that this is the " Joe."

Joe Crampton.— (Daniel Lock, Union Pier, Mich.) Said to have been found in an old patch of berries in Berrien County, Mich., by a Mr. Henry Gersandi and introduced by Mr. Lock in 1912. Its history is obscure. It is said to be grown quite extensively in Michigan for the Chicago market.

Plants below medium in vigor and number, severely injured by leaf-spot, unproductive; leaves variable in size, thick, light to medium green, rugose; flowers perfect, bloom in mid-season, variable in size, often from one to one and one-fourth inches across; petals roundish-oval, six to seven in number; stamens numerous, long; receptacle small, roundish; fruit-stems of medium length, slender, erect, single; calyx intermediate in size, flat to raised; seeds often sunken. Fruit matures very late; variable in size, very irregular, blunt-conic to wedge, sometimes necked, unattractive, somewhat dull, light red; apex variable in shape; flesh light red, whitish toward the center, very juicy, firm, sprightly; good in quality.

Inferior both in plant- and fruit-characters to other varieties of its season.

Jopp Favorite.— (W. S. Todd, Greenwood, Del.) A seedling of unknown parentage. originating with W. H. Jopp, Denton, Md., in 1911; introduced by Mr. Todd in 1916.

Plants numerous, vigorous, healthy, unproductive; leaves large, thick, dark green, rugose, glossy; flowers perfect, appear late, one and one-fourth inches across; petals large, roundish, six to eight in number; stamens numerous, long; receptacle of medium size, roundish-conic; fruit-stems long, intermediate in thickness, erect, branching; calyx of medium size, slightly raised; seeds raised. Fruit matures very late; unusually large, blunt-wedge, necked, dull, unattractive medium to dark red; apex blunt; flesh red thruout, juicy, firm, subacid; fair in quality.

Plant-habits desirable except in yield; a very late variety, with fruit of largest size which is well-retained thruout the season but which is too dull and unattractive in color and not of highest flavor.

Kellogg Prize.— (R. M. Kellogg Co., Three Rivers, Mich.) Said to be a chance seedling found in 1906 close to a brush heap near a field of berries and propagated by R. M. Sears, La Grange, Ill.; introduced in 1913 by the Kellogg Co.

Plants medium or below in number, intermediate in vigor, healthy, productive; leaves of medium size and color, thick, dull, rugose; flowers imperfect, appear in early mid-season, large, often more than one and one-half inches across; petals large, roundish-oval, six to eight in number; receptacle large, prominent; fruit-stems of medium length, thick, prostrate, branching; calyx large, raised, leafy; seeds often raised. Fruit matures late; above medium to large, blunt-conic to blunt-wedge, necked, medium to light red; apex slightly pointed; flesh light red thruout, juicy, firm, sprightly; fair to good in quality.

Plant-habits good; an imperfect-flowering variety, maturing late and shipping well; the later pickings were improvements in both size and color of fruit, the berries at that time making an unusually fine showing.

Knight No. 1.— (David Knight & Son, Sawyer, Mich.) A seedling of unknown parentage originating with Wm. H. Tracy, Gloucester, Ohio, about 1902; listed and described in the Knight catalog of 1916 as " No-Name-As-Yet;" not yet introduced.

Plants numerous, vigorous, healthy, very productive; leaves of medium size, thin, dark green, rugose; flowers imperfect, bloom in late mid-season, small, less than one inch across; petals small, usually five in number, roundish; receptacle small, roundish-conic; fruit-stems long, of medium thickness, semi-erect, branching; calyx intermediate in size, much raised, leafy, attractive green; seeds raised. Fruit matures late; above medium to large, conic to wedge, strongly necked, dull, very light red; apex pointed; flesh light red to the center, juicy, lacks in firmness, hollow at the core, mild, sweet; good in quality.

Fruit too light colored and too soft; surpassed by other varieties of its season.

La Bon.— (H. J. Schild, Ionia, Mich.) A seedling of unknown parentage grown by Mr. Schild in 1909; introduced in 1916 by leading small-fruit nurserymen of various states.

Plants numerous, vigorous, healthy, productive; leaves medium in size, thick, very dark green, smooth, glossy; flowers perfect, bloom in early mid-season, about one inch across; petals small, roundish, five to eight in number; stamens numerous, short; receptacle large, conical; fruit-stems of medium length and thickness, semi-erect, branching; calyx intermediate in size, flat; seeds raised, prominent. Fruit matures medium early; large, irregularly furrowed, oblate to roundish-oblate, glossy, light red, colors unevenly; apex obtuse, indented; flesh light red, becoming whitish toward the center, not juicy, medium in firmness, with hollow core, mild, not high-flavored; fair in quality.

Plant-habits unusually good; the long, dense root-system accounts for the designation " alfalfa-rooted " given by Mr. Sibert. Fruit is characteristic in the flattened shape, furrowed surface, hollow core, apex often broken apart, and the strongly raised seeds. Berries inclined to green tips, of desirable size but unattractive both in shape and color, and lacking in firmness.

Lady Corneille.— (W. F. Allen, Salisbury, Md.) Said to contain a mixture of the blood of Klondike, Bubach, Red Bird and Mary, originating in 1909 with Mrs. T. C. Corneille, Ponchatoula, La.; introduced in 1912 by Lee Lanier of that place.

Plants numerous, vigorous, usually healthy, unproductive; leaves small, thin, medium to dark green, smooth, glossy; flowers perfect, bloom early, one and one-fourth inches across; petals large, roundish-oval; stamens numerous, long; receptacle of medium size; fruit-stems short, thick, semi-erect, branching; calyx large, raised, leafy; seeds slightly raised. Fruit matures medium early; above medium in size, furrowed, wedge to blunt-conic, necked, often dark red; apex slightly pointed; flesh light red, becoming whitish toward the center, juicy, firm, sprightly, almost tart; fair in quality.

Plants unproductive; fruit strongly furrowed, inclined to green tips; the leafy calyx detracts from appearance; a good shipper but not of high flavor or quality.

McAlpine.— (W. F. Allen, Salisbury, Md.) A cross between Glen Mary and Bubach made by Hausmann Bros., Hilton, N. J., in 1909; developed by Louis Becker & Son of that place and in 1915 introduced by Mr. Allen.

Plants numerous, vigorous, injured by leaf-spot, productive; leaves small, thin, rather light green, smooth; flowers perfect, appear in early mid-season, one and one-eighth inches across; petals of medium size, roundish, five to eight in number; stamens numerous, long; receptacle small, roundish; fruit-stems long, slender, erect, single; calyx of medium size, slightly raised; seeds somewhat sunken. Fruit matures late; of large size, furrowed, blunt-wedge to blunt-conic, necked, dull, light red; apex indented, green-tipped; flesh light red, becoming whitish toward the center, very juicy, not firm, mild subacid; fair in quality.

Plant-habits good except in resistance to disease; a late-maturing variety with fruit of good size but inclined to green tips, rather soft for a good shipper, too light red for a very attractive berry, very light at the center, inferior in flavor and quality.

Magic Gem.— (R. M. Kellogg Co., Three Rivers, Mich.) A seedling of unknown parentage developed by Edw. Vance, Twin Falls, Idaho, in 1912; introduced by the Kellogg Co. in 1916.

Plants medium in number and vigor, healthy, productive; leaves rugose; flowers perfect, bloom in late mid-season; stamens medium in number, short; receptacle broad-conic; fruit-stems of medium length, thick, semi-erect, branching; calyx large, slightly raised, leafy, attractive green; seeds variable in position. Fruit matures in late mid-season; very large, dropping somewhat at the close of the season, broad-conic, with a few cockscombs, slightly necked, attractive medium red; apex somewhat pointed; flesh medium red to the center, juicy, very firm, the larger berries with a hollow core, pleasantly sprightly, high-flavored; very good in quality.

Plant-habits unusually good; a perfect-flowering variety blooming and ripening in late mid-season; altho the surface of the largest berries is furrowed and irregular, the general appearance is very attractive and the flesh-characters much above the average especially in quality; worthy of trial either for home use or commercial purposes.

Marshall Improved.— (E. W. Townsend, Salisbury, Md.) The history of this variety is obscure. It is stated in Mr. Townsend's catalog that he purchased this strain of Marshall from an agent canvassing in his territory. Nothing appears to be known regarding its origin.

Plants healthy, medium in number, vigor and productiveness; leaves of average size and thickness, light green, rugose; flowers perfect, large, often one and one-fourth inches across, bloom early; petals crinkly, broad-oval, five to eight in number; stamens numerous, long; receptacle large, roundish; fruit-stems short, thick, erect, branching; calyx large, flat or depressed, discolored; seeds variable in position. Fruit matures early; large to medium, irregularly furrowed, roundish-conic, light red, dull; apex obtuse; flesh light red, becoming whitish toward the center, medium in juiciness and firmness, mild subacid, not high-flavored; fair in quality.

As fruited at this Station the variety is no improvement on the Marshall, ranking decidedly inferior to that well-known variety nor does the fruit show much resemblance either in color or flavor.

Minnesota No. 3.— (Experiment Station, St. Anthony Park, Minn.) Originated by Chas. Haralson in 1909 at the Minnesota Fruit Breeding Farm, Excelsior, Minn. It is a cross between Dunlap and Pokamoke; introduced by the Experiment Station about 1914.

Plants numerous, vigorous, nearly free from leaf-spot, very productive; leaves of medium size, thickness and color, glossy, rugose; flowers perfect, bloom in early mid-season, one inch across; petals of medium size, roundish-ovate, five to seven in number; stamens numerous, medium in length; receptacle conical, rather small; fruit-stems intermediate in length and thickness, nearly prostrate, branching into long, slender pedicels; calyx large, much raised, attractive green, with long, reflexed sepals; seeds slightly sunken. Fruit matures medium early; large to medium, dropping in size as the season advances, conic, the base irregular, strongly necked, attractive, glossy, medium to dark red; apex distinctly pointed, often green-tipped; flesh red thruout, very juicy, firm, pleasantly sprightly; good in quality.

Resembles Dunlap in type, of good color and pleasing flavor; greatest defect appears to be lack of desirable size.

Minnesota No. 1017.— (Experiment Station, St. Anthony Park, Minn.) Originated at the Minnesota Fruit Breeding Farm, Excelsior, Minn., in 1909 by Chas. Haralson. A cross between Dunlap and Progressive. It is said to be one of the most promising everbearing strawberries produced at the Fruit Breeding Farm; introduced by the Experiment Station about 1914; an "everbearer."

Plants few in number, medium in vigor, nearly free from leaf-spot, very productive considering the number of plants; leaves small, thick, dark green, smooth, glossy; flowers perfect, open in early mid-season, one and one-eighth inches across; petals of medium size, roundish; stamens medium in number and length; receptacle roundish; fruit-stems above medium in length, thick, erect, branching; calyx flat, dingy green;

seeds raised. Fruit matures in mid-season; above medium, dropping to small, irregular-conic to blunt-wedge, broad and flat at the base, not very attractive, somewhat dull, medium red; apex obtuse; flesh red thruout, juicy, very firm, with hollow core, sprightly, almost tart; good in quality.

Altho very productive, the greatest defect appears in lack of size, as grown on the heavy clay of this Station.

Minnetonka.— (E. W. Potter, Leslie, Mich.) A seedling of Splendid crossed with Beder Wood in 1904; introduced in 1909.

Plants of medium number, vigor and productiveness, healthy; leaves small, thick, dark green, rugose, glossy; flowers perfect, bloom in early mid-season, one inch across; petals of medium size, roundish, six to seven in number; stamens intermediate both in number and in length; receptacle roundish-conic; fruit-stems very short, thick, prostrate, branching; calyx medium in size, flat; seeds raised. Fruit matures in early mid-season; inferior in size, blunt-wedge to blunt-conic, dull, unattractive medium red; apex somewhat pointed; flesh light red, juicy, very firm, sprightly; fair in quality.

This variety appears to have but little value as fruited on the Station grounds; easily surpassed by other varieties of its season.

Morgan No. 21.— (J. A. Morgan, Scottsville, N. Y.) A chance seedling found by Mr. Morgan in 1911 growing in a fence corner on his farm; not yet introduced.

Plants of but medium number, unusually vigorous and tall, healthy, very productive; leaves of largest size, thick, dark green, rugose; flowers imperfect, bloom in late mid-season, about one inch across, cup-shape and with a large, leafy, calyx; petals roundish, six to eight in number; receptacle medium in size, roundish-conic; fruit-stems very long, thick, erect, branching; calyx very large, depressed or flat, leafy, attractive green; seeds usually raised but variable. Fruit matures medium early to early mid-season; of largest size, dropping rapidly in size as the season advances, the largest berries irregularly furrowed, roundish-conic to blunt-wedge, some berries inclined to almost oblate, dark red, attractive, glossy, colors evenly; apex very obtuse, indented; flesh variable in color, very firm, juicy, somewhat sprightly; very good in quality.

A seedling with merits considerably above the average; plants unusually tall, vigorous and with very large leaves; must be planted with other varieties as the blossoms are imperfect; flowers peculiarly cup-like, with a large, leafy calyx; fruit-stems of longest size yet erect; calyx attractive in color; fruit almost fig-like in texture, one of the best of shippers, often truncate in shape; altho the later berries are not above medium size, they are uniform in general appearance, the smallest ones slightly seedy; quality much above the average run of seedlings; worthy of extended trial.

Myrtle Murrell.— (J. T. Lovett, Little Silver, N. J.) A seedling of Hoffman crossed with Heflin in 1905 by S. S. Murrell, Marion Station, Md.; introduced by Mr. Murrell in 1913.

Plants very numerous, medium in vigor, unproductive, injured by leaf-spot; leaves very small, thin, light green; flowers perfect, bloom early, over one inch across; petals roundish, six to eight in number; stamens very long, numerous; receptacle of medium size, roundish; fruit-stems short, slender, erect, single; calyx of medium size, raised, discolored; seeds raised. Fruit matures in mid-season; inferior in size, long-conic, slightly necked, unattractive, dull, light red; apex pointed; flesh light red, becoming whitish toward the center, juicy, variable in firmness, mild, sweet; good in quality.

Disappointing both in plant and fruit; a rather long, conical, light red berry inferior both in size and color.

Nellis Triumph.— (J. H. Nellis, Paterson, N. J.) A seedling of unknown parentage discovered by Mr. Nellis in 1912; introduced in 1917 by The W. F. Allen Co., Salisbury, Md. and by W. B. Kille, Swedesboro, N. J. It is thought by some to resemble Clyde.

Plants intermediate in number and vigor, healthy, very productive; leaves of medium size, color and thickness; flowers semi-perfect to perfect, open early, one and one-eighth inches across; petals roundish, six to eight in number; stamens numerous;

receptacle roundish-conic, of medium size; fruit-stems variable in length, thick, prostrate, branching freely into long, slender pedicels; calyx flat to slightly depressed; seeds variable in position. Fruit matures in early mid-season; large, retains size well thruout the season, blunt-conic, broad at the base, light red, dull; apex obtuse; flesh light red, very juicy, lacks in firmness, mild subacid; good in quality.

One of the most productive varieties, holding up well both in yield and size of fruit thruout the season; unfortunately the berries are too light and dull in color and bruise easily; of doubtful value in spite of its desirable flavor and quality.

Onward.— (Samuel Cooper, Delevan, N. Y.) A cross between Autumn and Cooper made in 1907 by Mr. Cooper and introduced by him in 1914; an "everbearer."

As grown on the soil at this Station, Onward cannot be distinguished from Advance and the reader is referred to that variety for description.

Oregon.— (Oregon Nursery Co., Orenco, Oregon.) This variety is said to be a cross between Marshall and Jessie made about 1898 by A. F. Hofstadtler, Salem, Oregon, first introduced in 1902 as Admiral Dewey, later was changed to Oregon and was recently re-introduced as New Oregon.

Plants numerous, of medium vigor, healthy, very productive; leaves small, intermediate in thickness and color; flowers perfect, appear early, one and three-eighths inches across; petals roundish, seven to nine in number; stamens numerous, short; receptacle large, very blunt, broad at the base; fruit-stems long, slender, erect, single; calyx of medium size, variable in position; seeds slightly raised. Fruit matures early; of large size which is well-retained thruout the season, very irregular in shape, averaging roundish-conic, attractive, glossy, medium to dark red, colors unevenly; apex blunt; flesh red thruout, juicy, firm, pleasantly sprightly; good in quality.

A very productive variety, maturing early; altho somewhat variable both in color and shape, appears worthy of test on account of high quality and pleasing flavor.

Pearl.— (L. J. Farmer, Pulaski, N. Y.) Said to have been originated by J. W. Loomis, Hobart, Indiana; a seedling of Gandy; introduced in 1912 by the originator. Statements are at variance in regard to the history of this variety.

Plants numerous, large, healthy, productive; leaves large, thick, medium green, rugose; flowers perfect, bloom very late, one and one-fourth inches across; petals roundish-oval, six to eight in number; stamens numerous, long; receptacle large, prominent; fruit-stems of medium length, very thick, erect, single; calyx large, flat or slightly raised; seeds raised. Fruit matures very late; very large, retaining size well as the season advances, irregularly furrowed, blunt-conic to wedge, sometimes slightly necked, medium to light red; apex obtuse, indented, not always well-developed; flesh well-colored to the center, juicy, very firm, sprightly; good in quality.

Plant-habits good; the late-blooming flowers are not subject to frost-injury; fruit matures among the very latest varieties, one of the best of shippers, as well as choice in size of berry, attractive in appearance except for a number of berries undeveloped at the apex; worthy of test for a sprightly, late variety of high quality.

Premier.— (R. M. Kellogg Co., Three Rivers, Mich.) A seedling of unknown parentage sent by E. H. Riehl, Alton, Ill., in 1912 to the Kellogg Company; introduced by that company in 1915.

Plants medium in number and vigor, healthy, productive; leaves small, of medium thickness and color, slightly rugose, dull; flowers perfect, season of bloom early, one and one-eighth inches across; petals roundish-oval, six to eight in number; stamens numerous, long; receptacle of medium size, conic; fruit-stems very short, thick, prostrate, branching; calyx large, raised to flat, attractive green; seeds sunken. Fruit matures medium early; above medium to small, long-conic to long-wedge, with furrow running from base to apex on the largest berries, necked, attractive, glossy, medium red; apex pointed; flesh red to the center, juicy, firm, often with a firm core, somewhat sprightly; good in quality.

A fairly good berry in flesh-characters but the shape is against it and the size is too small.

Rewastico.— (W. F. Allen, Salisbury, Md.) Said to be a seedling of unknown parentage originating with Thomas B. Howard of Wicomico County, Md., about 1908; introduced by Mr. Allen in 1913.

Plants produced in great numbers, vigorous, healthy, very productive; leaves of medium size and thickness, very dark green, nearly smooth; flowers perfect, intermediate in season of bloom, one and one-fourth inches across; petals large, roundish, five to seven in number; stamens numerous, long; receptacle of medium size, roundish; fruit-stems long, very thick, erect, single; calyx large to medium, leafy, usually slightly raised, with very broad sepals; seeds sunken. Fruit matures late; large, blunt-wedge to roundish-conic, slightly necked, attractive medium red, somewhat glossy; apex obtuse; flesh usually red thruout, very juicy, firm, tart, not pleasant-flavored; inferior in quality.

Characteristic in the large number of runners produced, making a wide row, and in the pleasing appearance at blooming time, the large, showy blossoms being scattered thickly among the dark green leaves; general appearance attractive in size, color and shape, but too sour for most palates.

Richmond.— (J. T. Lovett, Little Silver, N. J.) A seedling of Lady Thompson originating in 1901 with Mark T. Thompson, Richmond, Va.; introduced in 1903 by Mr. Thompson.

Plants few in number, of medium vigor, healthy, very productive; leaves thick, medium in size and color, rugose; flowers semi-perfect to perfect, bloom early, nearly one and one-fourth inches across; petals roundish, seven to eight in number; stamens numerous, long; receptacle of medium size, conic; fruit-stems intermediate in length and thickness, semi-erect, branching; calyx large, raised, with long, narrow sepals; seeds sunken. Fruit matures in mid-season; above medium to small, oblong-conic, necked, light red, not very glossy; apex pointed; flesh red thruout, juicy, firm, variable in flavor; fair in quality.

Blossoms showy; a light red berry characteristic in its long-conic shape; a good shipper but disappointing in size, shape and flavor.

Standpat.— (C. N. Flansburgh & Son, Jackson, Mich.) A seedling of Dunlap crossed with Pan American by Harlow Rockhill, Conrad, Iowa, in 1906 and introduced in 1914 by Flansburgh & Son. An "everbearer."

Plants very few, inferior in vigor, health and yield; leaves small, of medium thickness and color; flowers perfect, open early, very small, three-fourths inch across; petals of smallest size, five to seven in number; stamens variable in number and length; receptacle large for the size of the blossom, prominent; fruit-stems very short, slender, prostrate, single; calyx small, depressed, discolored; seeds prominent, raised. Fruit matures very early; medium to small, blunt-conic, dull, unattractive, dark red; apex variable in shape; flesh variable in color, juicy, medium in firmness, subacid; inferior in flavor; poor in quality.

For some reason both plants and fruit were practically a failure. Possibly might give different results another year or on another type of soil.

Todd.— (W. S. Todd, Greenwood, Del.) A chance seedling found by Mr. Todd in 1909 on his farm near a bed of Sample and Wm. Belt; introduced by Mr. Todd in 1914 as Todd's Late Champion.

Plants few in number, vigorous, injured by leaf-spot, productive; leaves very large, thick, dark green, rugose; flowers imperfect, variable in size, bloom late; petals broad-oval, five to seven in number; fruit-stems short, very thick, erect, branching; receptacle large, roundish-conic; calyx medium in size, flat to slightly raised; seeds sunken. Fruit matures very late; large to medium, wedge to blunt-conic, the larger berries furrowed and occasionally cockscomb in shape, unattractive light red, colors unevenly; apex obtuse; flesh light red, becoming whitish toward the center, medium juicy, lacking in firmness, somewhat sprightly; fair in quality.

Undesirable both in color of surface and flesh; too soft for a good shipper; surpassed by other varieties of its season.

Warren.— (W. F. Allen, Salisbury, Md.) Said to be a chance seedling found by S. H. Warren, Auburndale, Mass., many years ago; introduced by Mr. Allen in 1914.

a low egg count was secured. However, the difference between the sprayed and unsprayed sections is only 2.4 times its probable error, and so lacks certainty as a single experiment. It is possible that the adjoining unsprayed vineyard used as a check did not have as severe an infestation as Section 5, and thus a systematic error may mask the results. On the other hand, the rain occurring so shortly after the first spraying may have introduced a disturbing factor. Knowing that large numbers of beetles were present before the spraying, the few eggs deposited are indicative that we secured the desired results. Excellent results were secured in the Roosa vineyard where two applications of bordeaux mixture and arsenate of lead were properly applied. The fact that this mixture without poison gave practically the same egg count as where the arsenate of lead was used must not be given too great weight, for a similar experiment during 1914 indicated that the poison is necessary.

OBSERVATIONS AND FIELD TESTS DURING 1914.

At first it appeared that the Carabid beetles had again seriously interfered with the number of root-worm beetles, and for a time it was difficult to find vineyards sufficiently infested to be worthy of experimentation. Gradually, after the first beetles appeared, vineyard after vineyard that was severely infested was brought to our attention. Eight vineyards were found that answered all requirements and the difficulty of getting them all sprayed at the proper time, had to be surmounted. Seven of the vineyards were sprayed at the proper time. Another vineyard received a rather late application of molasses and arsenate of lead, but owing to unfavorable weather the bordeaux mixture and arsenate of lead spray was applied entirely too late to control the grape root-worm.

TESTS IN THE VINEYARD OF E. L. DAY, DUNKIRK.

This vineyard was situated on soil mapped as Dunkirk very fine sandy loam, and the surface is level. The vines were of moderate vigor, and severely infested with the grape root-worm. The rows extended north and south. The first beetles appeared in this vineyard on June 28. A portion of the vineyard, comprising eight rows, was sprayed with molasses and arsenate of lead, the usual quantities being used. This application was made on July 1, the day being cloudy with a light south wind and a maximum tempera-

ture of 72 degrees F. The remainder of the vineyard on either side of this plat was sprayed with commercial bordeaux mixture and arsenate of lead. No rain occurred between the first and second sprayings. The second application was made on July 8, and consisted of commercial bordeaux mixture, 12 pounds, arsenate of lead, 6 pounds, and water, 100 gallons. The sprayings were accomplished with a " traction " sprayer.

As evidence of the effectiveness of the sweetened spray, we mention the fact that twenty-four hours after the first spraying eleven dead beetles were picked up from under one vine, while smaller numbers were gathered from under other vines. To test this material further eighty-eight beetles that were gathered from the foliage of these vines, were placed in a cage in the insectary, and fed unsprayed foliage. All the beetles died in two days' time, while the majority died in 24 hours. Careful counts were made of the egg clusters on the vines sprayed with the sweetened poison and, in order to remove the influence of any systematic errors that might be present, vines were selected on each side of Plat 1 for egg counts. The results are given in Table VIII.

It will be noted that the average number of eggs per vine is rather high when compared with several other vineyards. The same is true of the vines sprayed with the commercial bordeaux, but the difference in the number of eggs on the two plats is significant, and the plat treated with molasses and poison has the lower number of eggs. Observations in this vineyard just after spraying revealed the fact that the commercial bordeaux mixture did not cover the foliage nearly as well as home-made bordeaux mixture, and did not remain on the foliage as long. This difference in " body " is believed to have decreased the repellent power, and this would explain the fact that more eggs were laid on the vines even tho the sweetened spray had killed most of the beetles originally on the vines. The results on plat 1 were of practical importance because the actual number of eggs per acre was greatly reduced.

TESTS IN THE VINEYARD OF MRS. C. M. BENJAMIN, FREDONIA.

This vineyard is situated on Dunkirk gravel soil. The first rootworm adults appeared on June 20, and were present in moderate numbers when the vineyard was sprayed on June 30. The rows extend from east to west. The vineyard was divided into three

plats: The one to the north was left as a check; the middle plat received an application of bordeaux mixture and arsenate of lead, and the plat to the south received an application of bordeaux mixture, arsenate of lead, and "Black leaf 40." The day was clear with a maximum temperature of 74 degrees F. and with a brisk southwest wind, but as the vineyard was protected by a woodland no trouble was experienced in applying the spray. Only one application was made, as this appeared to control the beetles.

From Table VIII we note that a decided decrease in the number of eggs per vine occurred in the sprayed plats, and that the differences of both plats over the check plat are marked. It is apparent that the use of nicotine in bordeaux mixture does not increase the effectiveness of the latter for the control of the grape root-worm since the number of eggs is very nearly the same in the two plats and the difference is only 0.2 of its probable error. The favorable results from a single spraying in this vineyard were due to the fact that the infestation was moderate, and the surroundings were such as to allow a small amount of infestation by migrating beetles. This result seems to bear out the contention that, in a moderately infested vineyard, a single timely spraying may occasionally hold the pest in check, provided the danger of reinfestation is not great.

TESTS IN THE VINEYARD OF HENRY BARNES, FREDONIA.

Section I of this vineyard is situated on practically level Dunkirk gravelly loam soil, while Section II was on slightly rolling Dunkirk gravel. The vines were vigorous and moderately infested with *F. viticida*. The rows in both sections extended north and south, and the plats were numbered from east to west. The first adults emerged in this vineyard on June 21 with the greater number emerging about July 1. The vines in Section I were sprayed on July 3. The day was clear with a light west wind and a maximum temperature of 72 degrees F. No rain appeared until July 12, or nine days later. Section II was sprayed on July 6. The day was clear with a light northwest wind and a maximum temperature of 82 degrees F. The comparisons sought were: Three brands of arsenate of lead (1) with each other and (2) with the check plat; (3) arsenate of lead and molasses with arsenate of lead and bordeaux mixture. Only a single spraying was given, as most of the beetles disappeared from the vines,

and as migrating beetles did not disturb conditions it was not considered necessary to give the additional application.

It will be noted (Table VIII) that the number of eggs found on the sprayed plats of Section I was small, and that the differences between the sprayed plats and the unsprayed plat were all marked, and indicate that the sweetened poison was responsible for the decrease in eggs. Especially is this difference significant when the mean of the three plats compared is considered. It is practically certain, however, that the several brands of arsenate of lead acted similarly for the differences are only such as might be expected from normal variation. In Section II the number of eggs on both plats is low, but the difference between them is not significant.

TESTS IN THE VINEYARD OF F. G. SPODEN, FREDONIA.

This vineyard was situated on Dunkirk silty clay loam, and the vines were young and vigorous. The surface of Section I was comparatively level but Section II, while nearby, was on an eastern slope. The rows extended north and south, and the plats were numbered from west to east. The northern portion of this vineyard — the part used for comparisons — was found to be severely infested with grape root-worm the latter part of June. The first beetles emerged on June 25, and by July 1 they were present in large numbers. The vineyard was sprayed late on July 3, and early on July 4. July 4 was clear, calm with a maximum temperature of 78 degrees F. In these tests: (1) Several brands of arsenate of lead were compared with each other; (2) the sweetened sprays followed with bordeaux mixture and arsenate of lead were compared with two sprayings with bordeaux mixture and arsenate of lead; (3) bordeaux mixture alone was compared with bordeaux mixture with arsenate of lead. The infestation was uniform on the several plats of each section where the egg counts were made, but Section II had a lighter infestation than Section I. The first rain occurred on July 12, or eight days after the first application. The second spraying was made on July 14, the day being fair with a light south wind and with a maximum temperature of 80 degrees F.

After the first spraying on Plat 1, Section II, it was noted that the beetles remained, and fed extensively. As it began to appear that this area would be seriously injured, and since we were convinced that the omission of the poison was responsible, it was decided

to add the arsenate of lead at the second application. Even with this second spraying the beetles laid many more eggs than in the adjacent plat. Three days after the first spraying it was noted that the beetles had almost disappeared from the molasses plats, but shortly afterwards more beetles were found on these vines. This is believed to have been due to the general dispersion and perhaps to the attractiveness of the molasses to the beetles. The migrants were avoiding the bordeaux-sprayed vines, and appeared to be moving to those sprayed with molasses; and the second spraying was made to check this movement.

A study of the data from this vineyard (Table VIII) will warrant the following conclusions: (1) All plats sprayed with molasses and arsenate of lead followed in due time with bordeaux mixture and arsenate of lead show small numbers of eggs per vine; (2) the mean difference of these plats over the plat sprayed with two applications of bordeaux mixture and arsenate of lead is significant; (3) the plats sprayed with the several brands of arsenate of lead gave uncertain differences, and so there is no reason to believe that important practical differences were present in the several forms of arsenate of lead, for the variation is very probably due to fluctuations in sampling, thus corroborating the results secured in the Barnes vineyard; (4) a single application with bordeaux mixture and arsenate of lead was far less efficient than two applications of the same material; (5) arsenate of lead in the bordeaux mixture is necessary for the control of the grape root-worm.

TESTS IN THE STATION VINEYARD, FREDONIA.

The entire vineyard, exclusive of Sections 2 (portion), 6 and 7, has each year received one or two sprayings of bordeaux mixture and arsenate of lead as necessity required. This we believe to have been necessary to keep the beetles within due bounds and to control the powdery mildew. While at first we were troubled with grape root-worm in Sections 2 and 5, no trouble was experienced in reducing the number of beetles, so no damage has been done by them. In sections 6 and 7 each year various sprays have been tried, and always a considerable number of vines have been left unsprayed to serve as checks. Here we have had numerous beetles each year. We also noted in Section 2 that, just as soon as we allowed the vines to remain unsprayed, the number of eggs laid was greatly increased, and that

a season's thoro spraying caused them to disappear to a great extent. Section 7 has had portions that were not treated each year, and here the beetles have remained. As described later (page 325) it appears that the action of the wind upon migrating beetles coming from unsprayed vineyards to the west as well as the isolation of sections 6 and 7 previous to 1913 has had considerable influence on the number of eggs deposited.

The experiments in 1914 consisted of a test of one application of bordeaux mixture and arsenate of lead with an unsprayed plat between these sprayed. The results are given in Table VIII, and it will be noted that there is considerable difference in the number of eggs on the sprayed and check plats, altho better results would doubtless have been secured had a second application been given.

TESTS IN THE VINEYARD OF W. E. SKINNER, PORTLAND.

This vineyard was situated on level Dunkirk gravelly loam soil, and was found to be severely infested with grape root-worm on July 8. We presume that the first adults appeared about June 25. The vines were moderately vigorous, and the rows extended north and south. The owner had sprayed the entire vineyard with bordeaux mixture and arsenate of lead, except one acre which was sprayed with molasses and arsenate of lead, on July 9. The day was fair, with a light northwest wind and a maximum temperature of 90 degrees F. The spraying was thoro, a " traction " sprayer being used, and only a single application was made. The first rain appeared on July 12.

The results (Table VIII) with both mixtures are not very good so far as the control of the grape root-worm is concerned, but the difference is in favor of the sweetened poison, and is significant. The high egg count is further proof that the failure to control the beetles in 1912 and 1913 was due to the lack of a second repellent spray applied at the proper time after the first application.

TESTS IN THE VINEYARD OF N. G. AND J. T. MERRITT, SHERIDAN.

The vines of this vineyard were of moderate vigor, and the portion in which the experiments were conducted was severely infested with *F. viticida*, especially in the southern ends of the plats where the comparisons were made. The soil is Dunkirk very fine sandy loam and almost level. The first beetles appeared on June 28, and

the majority had emerged by July 6. The rows extended north and south, and the plats were numbered from west to east. Tests were made with bordeaux mixture with both 6 pounds and 8 pounds of arsenate of lead; and with molasses with both quantities of arsenate of lead. This furnished comparisons of these plats with the check plat as well as comparisons between molasses and poison and bordeaux and poison. The first spraying was made on July 9, being applied by means of a gasoline engine sprayer. The day was fair, with a very light west wind (practically a calm) and a maximum temperature of 90 degrees F. Under such conditions it was possible to thoroly cover the foliage with spray. Within two days after the spraying it was found that practically all the beetles had disappeared from the molasses-arsenate of lead plats. In a few days there was a tendency for the vines to become re-infested, and therefore an application of bordeaux mixture and arsenate of lead was made on all plats on July 15. The first rain appeared July 23, eight days after the second spraying, but it was very light.

It will be noted in Table VIII that the number of eggs per vine on each sprayed plat decreases as we go from the west to the east. Since the plats sprayed with bordeaux mixture are to the west of the molasses plats, and also since plat 1 received less poison than plat 2 this condition might be expected. However, we note that plat 4 which received 6 pounds of arsenate of lead had less eggs than plat 3, which received 8 pounds of the same material, so we are of the opinion that a systematic error extends across the plats. If this is true the check plat had less eggs than would have been deposited on the other plats had they not been sprayed. Since the difference in the number of eggs on plats 1 and 2 is not significant we have combined them under the designation plat *a*, and plats 3 and 4 are combined and designated plat *b*. The check plat is lettered *c*. This arrangement makes fewer comparisons. Obviously no conclusion can be drawn from the difference between plats *a* and *b*, for this may be due entirely to a systematic error. The difference between plats *a* and *c* is in favor of plat *a*, but the difference is insignificant, due no doubt to the systematic error, but is included in the summary. The comparison between plats *b* and *c* shows a difference that perhaps is significant, because any systematic error that may have been present has tended to decrease this difference.

TESTS IN THE VINEYARD OF L. M. CARY, SHERIDAN.

In this vineyard the rows extend east and west, and the plats are numbered from north to south. Plat 1 was on rather level Dunkirk clay, but the soil changes rapidly to Volusia clay loam on plat 3, while plat 2 is intermediate in type, and these two latter plats are on more of a slope than plat 1.

We were not informed of the severe infestation in this vineyard until July 8, and an examination at this time revealed the insects in large numbers. We have no record of the appearance of the first beetles, but assume it to have been about June 28. Owing to the spraying operations in the Merritt vineyard and also because Mr. Cary did not purchase a sprayer until July 9, the molasses and arsenate of lead was not applied until July 10. The day was clear, but a rather strong breeze was blowing from the west which interfered with the proper application of the spray, altho the machine worked perfectly. The maximum temperature was 88 degrees F. Unfortunately, the following day very high winds set in, which, for almost a week, made it impossible to apply any spray. Thus the plat sprayed with molasses and arsenate of lead stood alone in the midst of four acres of unsprayed grapes; in other words, an excellent check was left on either side. Plats 1 and 2 were sprayed with bordeaux mixture June 17, but, unfortunately, by this time the beetles had laid most of their eggs. For this reason plat 1 also serves as a check, and furthermore shows that the second spray was applied too late to plat 2.

It will be seen in Table VIII that a rather large number of eggs were deposited on plat 2, just as was shown in our 1912 and 1913 experiments, where the second application was not made at the proper time. By comparing the number of eggs in plats 1 and 3 we note that the difference is 4.7 times its probable error, so it is very improbable that it is due to random sampling. Neither is it due to the late application of the bordeaux mixture and poison on plat 1, as this plat has a greater number of eggs than the check plat. Obviously we have a systematic error of sampling, and fortunately we can eliminate its effects by simply taking the average of plats 1 and 3. When this is done we find that plat 2 shows a large difference from the mean of plats 1 and 3. Since this difference is 13.5 times its probable error we have very great odds that the difference is due to the treatment given plat 2.

TABLE VIII.— DATA SECURED FROM VINEYARDS SPRAYED EXPERIMENTALLY FOR THE CONTROL OF THE GRAPE ROOT-WORM DURING 1914.

Plat.	Materials used.	Date of spraying.	Number of vines used for egg counts.	Average number of canes per vine.	Average number of egg clusters per vine.	Average number of eggs per vine.	Number of eggs per acre.	Comparisons. Plats compared.	Difference in number of eggs per vine.	Difference divided by its probable error.	Mean of similar comparisons in same vineyard.	Mean divided by its probable error.	Difference in number of eggs per acre.
	E. L. Day Vineyard, Dunkirk.												
1	Molasses, 1 gal; arsenate of lead, 6 lbs.; water, 100 gals. Commercial bordeaux mixture, 12 lbs.; arsenate of lead, 6 lbs.; water, 100 gals.	July 1 " 8	10	3.1	5.6	85±15	51,400	1 and 2	125±28	4.5	....	..	75,700
2	Commercial bordeaux mixture, 12 lbs.; arsenate of lead, 6 lbs; water, 100 gals.	June 30 July 8	20	3.0	9.4	210±23	127,100	......	....	....	....	..	.....
	C. M. Benjamin Vineyard, Fredonia.												
1	Not sprayed	......	10	3.9	6.0	156±34	94,400	1 and 2	108±37	2.9	110±25	4.4	66,600
2	Bordeaux mixture (8–8–100); arsenate of lead, 6 lbs.	June 30	10	4.0	2.1	48±14	29,000	1 and 3	112±35	3.2			
3	Bordeaux mixture (8–8–100); arsenate of lead, 6 lbs.; "Black Leaf 40," ½ pt.	" 30	10	4.0	2.8	44± 9	26,600	2 and 3	4±17	0.2	....	..	2,400
	Henry Barnes Vineyard, Fredonia. *Section I.*												
1	Brand A, arsenate of lead, 6 lbs.; molasses, 1 gal.; water, 100 gals.	July 3	10	3.1	2.0	27± 6	16,300	1 and 4	50±15	3.3	45± 9	5.0	27,200
2	Brand B, arsenate of lead, 6 lbs.; molasses, 1 gal.; water, 100 gals.	"	10	2.5	1.5	33± 9	20,000	2 and 4	44±17	2.6			
3	Brand C, arsenate of lead, 6 lbs.; molasses, 1 gal.; water, 100 gals.	"	10	3.2	2.3	36± 9	21,800	3 and 4	41±17	2.4			
4	Not sprayed	......	10	4.1	4.3	77±14	46,600	......	....	....	....	..	.....

TABLE VIII.— (*Continued*).

Plat.	Materials Used.	Date of spraying.	Number of vines used for egg counts.	Average number of canes per vine.	Average number of egg clusters per vine.	Average number of eggs per vine.	Number of eggs per acre.	COMPARISONS: Plats compared.	Difference in number of eggs per vine.	Difference divided by its probable error.	Mean of similar comparisons in same vineyard.	Mean divided by its probable error.	Difference in number of eggs per acre.
	Henry Barnes Vineyard, Fredonia. *Section II.*												
1	Bordeaux mixture (8–8–100); arsenate of lead, 6 lbs.	July 6	10	4.1	3.5	56±12	33,900	1 and 2	15±14	1.1	....	..	9,100
2	Molasses, 2 gals.; arsenate of lead, 6 lbs.; water, 100 gals.	"	10	2.9	3.0	41± 8	24,800	......	....	....	....	..	.....
	F. G. Spoden Vineyard, Fredonia. *Section I.*												
1	Bordeaux mixture (8–8–100), arsenate of lead, 6 lbs.	July 3	10	4.5	17.2	264±25	159,700	1 and 2	148±34	4.4	....	..	89,500
2	Bordeaux mixture (8–8–100), arsenate of lead, 6 lbs.	July 3 " 14	10	3.3	7.3	116±23	70,200	2 and 3	85±24	3.5	74±14	5.3	44,800
3	Brand A, arsenate of lead, 6 lbs.; molasses, 1 gal.; water, 100 gals. Bordeaux mixture (8–8–100), arsenate of lead, 6 lbs.	" 4 " 14	10	5.2	3.0	31± 6	18,800	2 and 4	72±25	2.9			
4	Brand B, arsenate of lead, 6 lbs.; molasses, 1 gal.; water, 100 gals. Bordeaux mixture (8–8–100), arsenate of lead, 6 lbs.	" 4 " 14	10	5.3	4.4	44±11	26,600	2 and 5	66±25	2.6			
5	Brand C, arsenate of lead, 6 lbs.; molasses, 1 gal.; water, 100 gals. Bordeaux mixture (8–8–100), arsenate of lead, 6 lbs.	" 4 " 14	10	4.8	3.3	50±10	30,300	3 and 4 3 and 5 4 and 5	13±12 19±12 6±15	1.7 1.6 0.4	....	.. .. ..	7,800 11,500 3,700
	Section II.												
1	Bordeaux mixture (8–8–100), no poison Bordeaux mixture (8–8–100), arsenate of lead, 6 lbs.	July 4 " 14	10	4.6	7.0	122±21	73,800	1 and 2	84±22	3.8	....	..	50,800
2	Bordeaux mixture (8–8–100), arsenate of lead, 6 lbs.	" 4 " 14	10	4.3	2.6	38± 7	23,000	......	....	....	....	..	.....

		Station Vineyard, Fredonia.												
	1	Not sprayed	......	23	3.4	14.9	340±23	205,700	1 and 2	231±25	9.2	....	..	139,800
	2	Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs	July 8	20	2.2	5.7	109±10	65,900	......	....	....	....	..	.....
		W. E. Skinner Vineyard, Portland.												
	1	Molasses, 1 gal.; arsenate of lead, 6 lbs.; water, 100 gals	July 9	20	2.5	5.3	100± 8	60,500	1 and 2	101±18	5.6	....	..	61,100
	2	Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs	"	20	2.4	8.3	201±16	121,600	......	....	....	....	..	.....
		N. G. & J. T. Merritt Vineyard, Sheridan.												
a	1	Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs	July 9 " 15	10	4.6	6.2	123±24	74,400	1 and 2	45±29	1.6	....	..	27,200
a	2	Bordeaux mixture (8-8-100), arsenate of lead, 8 lbs	" 9 " 15	10	5.5	4.2	78±17	47,200	3 and 4	23±14	1.6	....	..	13,900
b	3	Molasses, 1 gal.; arsenate of lead, 8 lbs.; water, 100 gals Bordeaux mixture (8-8-100); arsenate of lead, 6 lbs	" 9 " 15	10	3.7	3.3	67±11	40,500	......	....	....	....	..	.....
b	4	Molasses, 1 gal.; arsenate of lead, 6 lbs.; water, 100 gals Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs	" 9 " 15	10	2.8	3.1	44± 9	26,600	......	....	....	....	..	.....
	c	Not sprayed	......	10	4.0	8.0	154±33	93,200	a and b	45±16	2.8	....	..	27,200
	a	Bordeaux mixture and arsenate of lead	......	20	....	5.2	101±15	61,100	a and c	53±36	1.5	....	..	32,100
	b	Molasses and arsenate of lead	......	20	....	3.2	56± 7	33,900	b and c	98±34	2.9	....	..	59,300
		L. M. Cary Vineyard, Sheridan.												
	1	Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs. (application too late)	July 17	10	4.1	12.9	290±18	175,500	1 and 3	104±22	4.7	....	..	63,000
	2	Molasses, 1 gal.; arsenate of lead, 6 lbs.; water, 100 gals Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs. (application too late)	" 10 " 17	10	3.7	4.8	90±17	54,500	Average (1-3) and 2	148±11	13.5	....	..	89,500
	3	Not sprayed	......	10	3.4	9.3	186±12	112,500		....	....	....	..	.....
	Av. (1-3).	See text	......	20	3.8	11.1	238±14	144,000	......	....	....	....	..	.....

A summary of the results of the experiments made during 1914 will be considered after the experiments conducted during 1915 have been discussed.

OBSERVATIONS AND FIELD TESTS DURING 1915.

TESTS IN THE VINEYARD OF FRED DENSON, SHERIDAN.

Altho several vineyards were found that were severely infested with the grape root-worm, only one suitable for field tests was available: that of Fred Denson, near Sheridan. This vineyard had been severely infested during 1914 but no treatment had been given, so that the injury was marked and an immense number of beetles appeared in 1915. The soil is Dunkirk clay and the section for the most part sloped gradually to the north, but the northern end was rather abrupt. The rows extended north and south.

The first adults appeared on July 9, but the emergence was slow, and so the majority of beetles did not appear until about one week later. Observations in this vineyard indicated that a systematic error of infestation extended across the section from east to west, therefore the placing of the plats was such that correction could be made for such an error if it appeared in the data; viz, the plats were repeated on either side of the central plat. Furthermore it was desired that the check plat should be least affected by the influence of the sprayed plats, and was also planned to correct for systematic error. This was accomplished by placing the check plat at the ends of the sprayed plats and making it of sufficient size to extend across the section (Fig. 7).

The first application of spray was made on July 20 and 21, followed by the second spray on July 31. A Brown horse-power sprayer was used. The application of the first spray was delayed several days by rain and threatening weather, but by the afternoon of July 20 it appeared that fair weather could be expected for several days, and the spraying was started. However, a trace of rain fell in the evening, which was not sufficient to affect the sprayed vines. The maximum temperature was 82 degrees F. and a very light west wind was blowing. July 21 was partly cloudy, with a maximum temperature of 85 degrees F. and a very light north wind. No rain fell for four days, but from July 26 to 30 the precipitation was 1.29 inches, and this removed the material on the plats sprayed with molasses and arsenate of lead. July 31 was cloudy,

with a maximum temperature of 89 degrees and a light northwest wind. On the following day the precipitation was .71 inches, and considerable rain fell for nearly a week. This, however, did not affect the vines sprayed with bordeaux mixture and arsenate of lead sufficiently to influence egg laying by the beetles. The applications given the various plats, and the results of the treatments are shown in Table IX.

It will be noted that no systematic error extended across the plats, as those treated similarly gave nearly the same number of eggs per vine. Furthermore the data obtained in three portions of the check plat were practically the same. In order to make comparisons

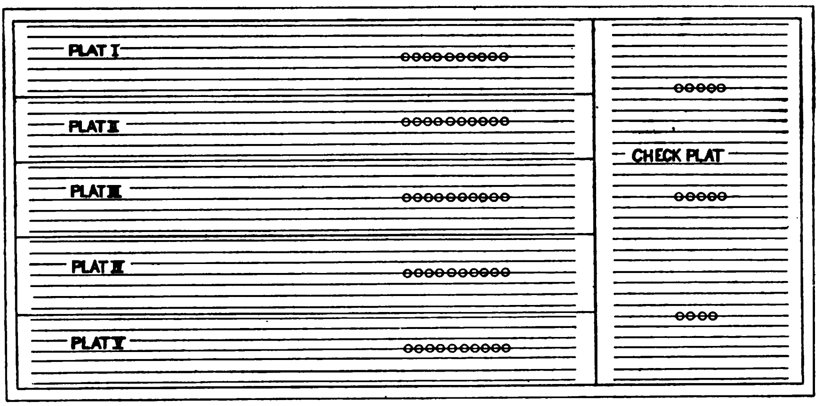

Fig. 7.— MAP OF VINEYARD OF FRED DENSON, SHERIDAN, SHOWING LOCATION OF PLATS.

between the materials used the plats treated alike are averaged and designated plats *a* and *b*.

The following points are emphasized by the data:

1. All treated plats had a much smaller number of eggs per vine than the check plat, and the differences are highly significant.

2. The plats sprayed with molasses and arsenate of lead followed with bordeaux mixture and arsenate of lead gave lower egg counts than the plat sprayed twice with bordeaux mixture and arsenate of lead. The means of these plats, however, when compared with plat 3 did not give significant differences.

TABLE IX.— DATA SECURED IN VINEYARD OF FRED DENSON, SPRAYED FOR THE CONTROL OF GRAPE ROOT-WORM. SHERIDAN, 1915.

Plat.	Materials Used.	Dates of sprayings.	Number of vines used for egg counts.	Average number of canes per vine.	Average number of egg clusters per vine.	Average number of eggs per vine.	Number of eggs per acre.	Comparisons. Plats compared.	Difference in number of eggs per vine.	Difference divided by its probable error.	Difference in number of eggs per acre.
1	Molasses, 2 gals.; arsenate of lead, 6 lbs.; water, 100 gals.; Bordeaux mixture (8-8-100); arsenate of lead, 6 lbs.	July 20, " 31	10	3.2	2.6	45± 9.6	27,200	1 and 4	1.5±11.6	0.1	900
2	Molasses, 1 gal.; arsenate of lead, 6 lbs.; water, 100 gals.; Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs.	July 20, July 31	10	4.9	3.8	82.5±16.5	49,900	2 and 5	12.5±22.0	0.6	7,550
3	Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs.	July 21, July 31	10	3.3	6.1	101 ±24.4	61,100	3 and 6	315.0±44.3	7.1	190,600
4	Molasses, 2 gals.; arsenate of lead, 6 lbs.; water, 100 gals.; Bordeaux mixture (8-8-100), arsenate of lead, 6 lbs.	July 21, July 31	10	2.6	2.8	43.5± 6.5	26,300	a and 6	371.7±37.5	9.9	224,900
5	Molasses, 1 gal.; arsenate of lead, 6 lbs.; water, 100 gals.; Bordeaux mixture (8-8-100); arsenate of lead, 6 lbs.	July 21, July 31	10	4.3	4.3	70.0±14.6	42,350	b and 6	339.7±38.6	8.8	205,500
6	Check	......	14	4.8	18.4	416.0±37.0	251,700	a and b	32.0±12.4	2.6	19,400
a	Average of plats 1 and 4	......	20	2.9	2.7	44.3± 5.8	26,800	a and 3	56.7±25.1	2.3	34,300
b	Average of plats 2 and 5	......	20	4.6	4.1	76.3±11.0	46,200	b and 3	24.7±26.8	0.9	14,900
								......	....	......	....
								......	....	......	....

3. The use of two gallons of molasses in the spray reduced the number of eggs to a greater extent than one gallon, but here again the difference is less than three times its probable error which causes some uncertainty to be attached to the results.

4. The favorable control of the grape root-worm with sweetened poison in this vineyard was due largely to the fact that the weather was carefully observed, and the applications made at a time when fair weather was expected for several days, and also that a proper interval of time had elapsed when the spraying with bordeaux mixture and arsenate of lead was made. It may be added that all the applications were made very thoroly.

DISCUSSION OF RESULTS OF EXPERIMENTS DURING 1914 AND 1915.

From the data in Tables VIII and IX the following features are apparent:

Two sprayings with bordeaux mixture and arsenate of lead applied at the proper time gave a marked decrease in the number of eggs as compared with the check plat (Merritt and Denson vineyards).

A single application of bordeaux mixture and arsenate of lead at the proper time caused a decreased number of eggs to be deposited (Benjamin and Station vineyards). However too much emphasis must not be placed on a single application as the results will depend largely on the environment, especially freedom from re-infestation. In the Spoden vineyard a single spray allowed many more eggs to be deposited than on the adjoining plat which received two applications of the same material. In this vineyard bordeaux mixture without poison gave poor results, and also in the Cary vineyard the same mixture with arsenate of lead applied too late, was a failure so far as the control of the root-worm was concerned.

A single spraying with molasses and arsenate of lead gave a decrease in number of eggs over the number found on the check plats (Barnes and Cary vineyards). This practice is not to be recommended, as in previous seasons a single application gave poor control.

Molasses and arsenate of lead followed in a week or ten days by bordeaux mixture and arsenate of lead gave a marked decrease in eggs over the check plat (Merritt and Denson vineyards).

Molasses and arsenate of lead followed in a week or ten days by bordeaux mixture and arsenate of lead in comparison with two

applications of the latter mixture decreased the number of eggs in every instance (vineyards of Day, Spoden, Merritt and Denson).

In the Barnes vineyard single applications of the two mixtures gave results in favor of the sweetened poison, but it should be stated that in previous years the reverse was true.

It must be remembered that the favorable results secured from single sprays in 1914 were due to the favorable climatic conditions (lack of rain) which existed for some time after the sprays were applied and that in 1912 and 1913 when more rain occurred during the spraying season the use of a single spray of molasses and arsenate of lead was a failure in every instance.

An application of two gallons of molasses per 100 gallons of mixture gave better control than one gallon (Denson vineyard) but the results are not without uncertainty.

Tests and comparisons of the leading brands of arsenate of lead indicated that, so far as the control of the grape root-worm is involved, no difference exists between the several brands.

DECREASE IN NUMBER OF GRAPE ROOT-WORMS DURING THE PERIOD 1912 TO 1918.

There has been considerable fluctuation in the numbers of *F. viticida*, at various times, since 1900, but usually there were present each year sufficient beetles to cause considerable damage thruout the Chautauqua grape region. Certain years the excessive numbers caused much damage. Since 1912 in the Chautauqua county vineyards there has been a steady decline in the number of adult beetles each summer with a consequent lessening in the number of eggs laid, thus permitting fewer larvæ to feed on the roots. At the present writing there are few vineyards infested sufficiently to demand remedial measures. While all the factors causing these fluctuations are not known, it is believed that so far as the present decline is concerned, several species of ground beetles (Family, Carabidæ) have exerted an important influence. The adults as well as the larvæ (at least of the larger species) of these carnivorous insects eat the grape root-worm. We have observed several severely infested vineyards in which the root-worms later were practically annihilated by the ground beetles. The decrease in numbers of *Fidia* have been so marked as to prevent the continuation of field experiments for their control during the period of 1916 to 1918, inclusive.

MISCELLANEOUS EXPERIMENTS RELATED TO GRAPE ROOT-WORM CONTROL.

EXPERIMENT TO TEST THE EFFECT OF WIND ON THE FLIGHT OF *Fidia viticida*.

The relation of the direction of the wind to the dispersion of the adults of *Fidia viticida* has a practical bearing on the results of treatment, the placing of check plats and on the question of infestation of new vineyards. It has been generally believed that the beetles fly with the wind, and in order to test this point more fully the following experiment was carried out.

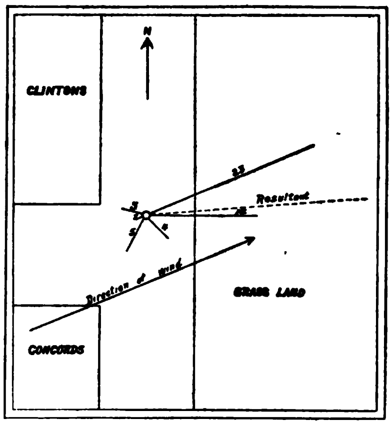

Fig. 8.— DIAGRAM SHOWING RELATION OF APPARATUS TO ENVIRONMENT AND DIRECTIONS TAKEN BY THE BEETLES.

The length of each line represents the number of beetles going in the direction indicated. Figures are number of beetles observed.

Fifty beetles were captured and placed in a wide mouthed bottle; within fifteen minutes the bottle was set in a saucer of water so as to prevent the beetles from crawling away, and the bottle opened. This apparatus was first placed on the platform of a wagon scale which was on the leeward side and distant about thirty feet from Concord vines. The scales were on the top of an escarpment exposed to the light southwest wind and the land sloped abruptly at least to sixteen feet below the level of the scales. This was at 4 P. M., but the wind appeared to be too strong, and the beetles refused to fly.

On the following day the same outfit was taken to low land, and placed on the ground in the position shown in the diagram (Fig. 8). The nearest vines to the leeward were at least one-eighth of a mile distant, the intervening land being in grass. A row of Clinton grapes was only six feet distant but to the windward, while at nearly a right angle to the direction of the wind and twelve feet distant were Concords. The day was clear, temperature was 75 degrees F. and the time from 10 to 11 A. M. The wind varied in velocity; at times there was a calm for a minute or two, and at no time was the wind

strong, being generally from the west-southwest. Twenty-three beetles flew directly with the wind, fourteen flew to the east, four flew at right angles to the wind (i. e., south-southeast) when its velocity was very low. During periods of calm one beetle flew directly opposite to the prevailing wind, three flew to the Clinton grapes and five to the Concords.

The experiment was made on July 19, 1913, during the period of dispersion. From this experiment we conclude: (1) That the general tendency of the beetles is to fly with the wind; (2) that they do not appear to migrate to any extent when the wind is brisk; (3) that Concord vines are considerably more attractive to the grape root-worm than Clintons. This is also corroborated by the fact that the author has never found a Clinton vineyard severely infested by this species. Altho the beetles flew with the wind, and altho there were no vines in sight in this direction, many of them alighting on grass stalks, this does not determine whether they will leave grape vines and fly with the wind without vines being in sight towards which they might fly. The observations of the author would indicate that this does not usually take place, unless there is an abundance of beetles in a vineyard. The more usual tendency in isolated vineyards is for the beetles to remain in a restricted area. This accounts for the fact that such vineyards may be severely infested for a series of years, and the author believes that in such isolated vineyards it is much more difficult to repel the insects from the vines by means of bordeaux mixture and poison than is usually found in infested areas adjoining other vineyards. In such vineyards the author has found that the bordeaux mixture gave poor results in controlling the pest, whereas in vineyards not isolated the same material applied under similar conditions gave excellent results. It is believed that the more usual manner is for the adults, singly — not in swarms — to fly short distances from vine to vine in the direction of the prevailing wind.

Several attempts to repeat this experiment at other seasons, resulted in failures because of the refusal of the beetles to fly. There is the possibility that the dispersion period had not been reached, and so the beetles were disinclined to move about to any great extent.

TESTS WITH ARSENITE OF ZINC.

Arsenite of zinc was one of the new insecticides during 1912, and since it was claimed to possess certain advantages over arsenate of lead tests were made to determine its effect both on Concord grape foliage and on the grape root-worm.

On June 22, 1912, ten vines were sprayed, using arsenite of zinc at the rate of six pounds in 100 gallons of water; and on June 24 ten additional vines were sprayed, using the formula: arsenite of zinc, 6 pounds, molasses, 2 gallons, and water, 100 gallons. The weather was hot and dry until July 11, when there followed a series of rainy and cloudy days until July 14. No injury was apparent on any of the sprayed vines until July 16, but from that date the "burning" became more marked, and by July 26 the vines on both plats dropped all their foliage.

Inasmuch as the preliminary tests with this insecticide showed no injury to the foliage by July 8, on that date we sprayed nearly one acre of Concord vines with the following mixture: arsenite of zinc, 3 pounds, molasses, 2 gallons, and water, 100 gallons. Our object in this test was to determine the effectiveness of this poison in decreasing the number of eggs laid by *F. viticida*. Many dead beetles were found under the vines the following day. However, on July 16 we began to see evidences of injury to the fruit and foliage, and in ten days every vine had had practically all its foliage destroyed and the fruit that was not injured by the spray had shrivelled because of the loss of foliage. The nature of the injury is shown in Plate IX, Fig. 1, and Plate X. The vines were not killed, but it required four seasons of careful handling to bring them to their original vigor and productiveness.

In a nearby vineyard on July 13, during a lull in the rainy period, we applied to Concord grapes 100 gallons of bordeaux mixture (8–8–100) to which was added 2 pounds of arsenite of zinc. Here no injury developed. Further experiments during the same season proved that the excess of lime in the bordeaux mixture counteracted the injurious principle in the arsenite of zinc. We are inclined to the opinion that the lime combined with the arsenic that became soluble during the wet period, and thus protected the vines. The relation of the weather to the injury described is clearly shown. Hot, dry weather permitted the material to produce no effect, while the rains and cloudy weather made conditions favorable for injury

to the foliage. Inasmuch as no advantage was indicated for arsenite of zinc over arsenate of lead, and since it has the disadvantage of lack of adhesiveness and uncertainty of safety to grape foliage, no further tests with this material have been made.

THE EFFECT OF MOLASSES ON THE ADHESIVENESS OF ARSENATE OF LEAD.

During the winter of 1912–13 about 500 tests were made with different brands of arsenate of lead and other insecticides, to determine their adhesive properties either alone or with other materials. The tests were made on glass plates, and the washing was accomplished by means of a rose sprinkler in the laboratory. The details of these experiments have been published and the reader is referred to the original article [1] for the description of the apparatus and the methods employed. However, for the purpose of interpreting the data of field tests, the table of characteristic data and the conclusions deduced are herewith reproduced.

From Table X we note (1) that the percentage of material remaining on the plates after sprinkling differs considerably with the different brands of leads; (2) no dry arsenate of lead proved as adhesive as the better adhering paste arsenates of lead; (3) several of the brands of paste arsenate of lead had poorer adhesive qualities than the brands of dry arsenate of lead; (4) in every instance, save one, the addition of molasses to an arsenate of lead lessened its adhesive properties, and this decrease in sticking power was greater in some brands than in others; (5) molasses greatly decreased the adhesiveness of a commercial preparation of bordeaux mixture and arsenate of lead; and (6) cane sugar used in practically the same amount as contained in molasses caused marked lack of adhesiveness in arsenate of lead; therefore we believe that the sugar contained in the molasses is largely responsible for the decreased power of adhesion in the experiments previously reported in this study.

SUMMARY OF CONTROL EXPERIMENTS FROM 1910 TO 1915.

The aims of the field tests described in this bulletin were two: the investigation of the value of bordeaux mixture and arsenate of lead in controlling the grape root-worm; and, the development of

[1] Hartzell, F. Z. The influence of molasses on the adhesiveness of arsenate of lead. *Jour. Econ. Ent.* 11: 62–66. 1918.

TABLE X.— DATA OF ADHESIVE TESTS.

Material applied to plates.	Average amount of material on plates after drying 24 hours and before sprinkling.	Average amount of material on plates after sprinkling and later drying for 24 hours.	Percent of material remaining on plates.	Number of plates used.
	Grams.	Grams.		
Brand A, a paste arsenate of lead without molasses	.0587	.0017	2.9	5
Brand A with molasses	.2632	.0012	*2.0	5
Brand B, a paste arsenate of lead without molasses	.0424	.0024	5.7	5
Brand B with molasses	.1452	.0002	*.5	5
Brand C, a paste arsenate of lead without molasses	.0580	.0509	87.8	5
Brand C with molasses	.1611	.0158	*27.2	5
Brand D, a paste arsenate of lead without molasses	.0353	.0140	39.6	3
Brand D with molasses	.1426	.0046	*13.0	3
Brand E, a dry arsenate of lead without molasses	.0479	.0039	8.1	2
Brand E with molasses	.1814	.0047	*9.8	2
Brand F, a dry arsenate of lead without molasses	.0707	.0079	11.2	2
Brand F with molasses	.2070	.0045	*6.4	2
Brand G, a paste arsenate of lead without sugar	.0546	.0089	16.3	3
Brand G with cane sugar	.1564	.0016	*2.9	2
Brand H, a commercial preparation of Bordeaux and lead without molasses	.0501	.0438	87.4	5
Brand H with molasses	.1840	.0016	*3.2	5

*In the tests in which molasses was added we have assumed that the same amount of insecticide was added that was found on the plate of the same brand without molasses and have calculated the percentage retained using this amount as the base.

a method of using sweetened poison so as to make a more efficient treatment for combating the adults than is bordeaux mixture and poison alone. In attempting to achieve the latter result, owing to the fact that the lack of adhesiveness of the molasses and arsenate

of lead spray was not known, reverses were suffered during several seasons. Finally it has been demonstrated that the sweetened spray should be applied when a large number of adults are present and at a time when there are good reasons for expecting fair weather for several days following the spraying, the object being to kill as many of the beetles as possible; then, in about one week follow the treatment with a thoro spraying with bordeaux mixture and arsenate of lead to repel all invading beetles as well as to prevent oviposition by the females remaining in the vineyard.

In all the field tests, two sprayings with bordeaux mixture and arsenate of lead applied thoroly and at the proper time have given effective control. In a few instances, when the infestation was not too intense and also where the danger of re-infestation was not great, a single application of this material has produced a marked reduction in the number of eggs.

The causes of failure to control with bordeaux mixture and arsenate of lead were three: (1) making the applications too late; (2) too long an interval of time between the first and second applications; and (3) lack of thoroness. This last condition has been largely due to efforts to spray when the wind was too strong, poor spraying apparatus or to vines trained so as to allow a clumping of the foliage.

The use of bordeaux mixture without poison was variable in its effects. In a test during 1913 the lack of poison did not permit the deposition of more eggs than where the arsenate of lead was used, but in a similar test in 1914 the lack of poison allowed many more eggs to be deposited than were found on the adjoining bordeaux and lead plat.

A combined spray for the grape leaf-hopper and the grape root-worm was not possible, at least during certain seasons, owing to the fact that the periods for effective control of these two insects do not coincide.

The use of nicotine sulphate with bordeaux mixture and arsenate of lead did not injure Concord grape foliage in any instance.

Twenty pounds of glucose and arsenate of lead with 100 gallons of water did not control the root-worm as effectively as bordeaux mixture and lead. Furthermore, owing to the lack of odor it was not as attractive to the beetles as one gallon of molasses in the same amount of water, and, as it destroys the adhesiveness of the poison to the same extent as molasses, field tests with glucose were discontinued.

The molasses and arsenate of lead spray applied at a time when rains did not occur for several days, followed in a week or ten days with bordeaux mixture and arsenate of lead proved more efficient in combating the grape root-worm than two applications of the latter mixture. Occasionally the omission of the bordeaux mixture and poison after the spraying with molasses and lead was effective, but the practice is very apt to result in failure as happened in the field tests during 1912 and 1913.

The addition of molasses destroys the adhesiveness of the arsenate of lead and the failure to appreciate this fact resulted in lack of control of the root-worm in several vineyards during 1912 and 1913. Another cause of failure was the allowing of too great an interval between the application of the molasses spray and the bordeaux mixture and poison.

Two gallons of molasses to each 100 gallons of spray material decreased the number of eggs per vine considerably more than one gallon both in 1911 and 1915. While the individual differences show some uncertainty the fact that similar results were secured both seasons indicates that considerable confidence can be placed in the data.

Arsenite of zinc when used alone or with molasses seriously injured grape foliage.

RECOMMENDATIONS.

Control of the grape root-worm.— If the beetles are moderately numerous, spray within a week of the appearance of the first adults, using bordeaux mixture (8–8–100) and 6 pounds of arsenate of lead. Repeat the application in about ten days. If, however, the beetles are present in excessive numbers, spray, as soon as the beetles appear in abundance on the vines, with molasses, 2 gallons, arsenate of lead, 6 pounds and water, 100 gallons. The application should be made when the weather conditions are such that no rain is to be expected for three or four days. Spray a second time one week later using bordeaux mixture (8–8–100) and arsenate of lead, 6 pounds All applications should be thoroly made. Inasmuch as the beetles are more active during warm days, better results have been obtained by applying the molasses mixture on such days providing rains were avoided.

Climatic conditions will determine the interval of time between applications. During hot weather the interval should be shorter

than during cool periods. Seasons having numerous showers the latter part of June or early July and vineyards whose environment is such as to permit of a continuous re-infestation may make necessary three treatments when the grape root-worm is abundant. Serious re-infestation may be expected where the sprayed vines are to the leeward — judged by the direction of the prevailing wind — of a seriously infested vineyard because the beetles fly with the wind.

The cumulative effect of bordeaux mixture and arsenate of lead upon the number of beetles is marked. Altho this material may not give as decided results as the sweetened spray when used for a single season on a vineyard severely infested with the grape root-worm, nevertheless the use of this material over a period of years in the same vineyard produces an appreciable decrease in the numbers of these beetles.

Materials.— A cheap stock molasses, owing to its more pronounced odor, is to be preferred to the more refined grades.

The better brands or grades of paste arsenate of lead are recommended for the poison in the spraying of grapes because of their adhesiveness and safety to foliage.

The home-made bordeaux mixture was found to be the cheapest and most practical form of this spray to apply. Concentrated prepared bordeaux mixture was found to be less adhesive, more expensive, and did not assist in the control of the beetles as well as the home-made product. The use of substitutes for either bordeaux mixture or arsenate of lead has usually resulted in severe injury to the foliage, and is not recommended except experimentally, and then on only a few vines. Many vineyardists have suffered severe losses from the use of untried preparations. Molasses should not be added to bordeaux mixture as injury to foliage may occur and in addition the latter mixture destroys the attractiveness of the molasses for the beetles.

Use all formulas as recommended. The addition of other substances or the changing of the proportions of the several constituents of a formula may produce injury. A mixture that is safe for another crop may not be safe for the grape. Even different species of grapes vary in their susceptibility to injury from certain preparations. The mixtures recommended above were found to be safe on every variety of grape upon which they were tried.

INSECT INJURIES OF APPLE FRUIT.*

The purpose of this circular is to help the fruit grower to distinguish the different kinds of insect injuries that appear on the fruit at picking time. In many cases the work of the insect is quite characteristic and often more conspicuous than the pest itself. When the grower has once learned to recognize these defects he can easily tell which insects are least under control in his orchard and can modify his spraying practices accordingly.

Only those insects are considered which attack the fruit itself, and the extent of this injury is not always a measure of the damage caused by a particular species. Many serious pests do not work on the fruit at all. There are some insects which destroy more fruit than is apparent from the results at picking time. For example, bud-moth larvæ and leaf-rollers cause many of the young fruits to drop so that evidence of the injury is not present later in the season.

* Reprint of Circular No. 57, February 20, 1918.

KEY FOR THE IDENTIFICATION OF INSECT INJURIES TO APPLES AS THEY APPEAR ON THE MATURE FRUIT.

A. Burrows in the interior of the fruit or mines beneath the surface.

1. With a cavity about the core or a small burrow leading toward the core, often with some surface feeding or mining around the entrance hole. Codling moth. *(1)
2. Feeding cavity usually an irregular blotch mine just beneath the skin. Lesser apple worm. (2)
3. With numerous winding burrows of small size in all parts of the flesh. Apple maggot. (3)

B. Brown scars and open cavities, having hard, corky surface, usually accompanied by more or less distortion of the fruit.

1. Pale brown, smooth scars, with thin, scattered dark brown scales, usually situated in a depression in the side of the apple. May be the work of any of the following early feeding worms, but the first-named is the most frequent cause.
   - Green-fruit worm. (4)
   - Fruit-tree leaf-roller. (5)
   - Oblique-banded leaf-roller, 1st brood. (6)
   - Bud moth. (9)
   - Palmer worm. (6)
2. Scars or open cavities with a thick, hard surface, which may be broken up into dark brown corky scales.
   - (a) Mostly shallow excavations.
     - Oblique-banded leaf-roller, 2nd brood. (11)
     - White-marked tussock-moth. (11)
   - (b) Deep, irregular pits. Rose chafer. (7)
3. Pale brown semi-circular or round scars situated in a slight depression or protruding. Plum curculio. (8)
   (Early oviposition and feeding punctures.)

C. Shallow excavations, deep pits or small holes made in the nearly mature fruit, and thus without a thick, corky surface and without distortion of surface of fruit.

1. Shallow excavations made under a leaf fastened to the surface of the fruit.
   - Oblique-banded leaf-roller. (11)
   - Bud moth. (9)
2. A small area of excavation or mining under the surface. Codling moth (late individual). (1)
3. Small round holes, less than 1/16 inch wide, leading into a small shallow mine under the skin. Casebearers. (10)
4. Round holes 1/16 inch to 1/8 inch wide leading into a rounded cavity somewhat larger than the opening. Plum curculio. (8)

D. Dimples or conical-shaped pits in the surface of the fruit.

1. With a brown scar at the bottom.
   - (a) Irregular depressions. Plum curculio. (8)
     (Early feeding punctures.)
   - (b) Symmetrical, conical-shaped pits. A section cut thru the pit shows a hardened line leading toward the center of the apple. Apple curculio. (13)
2. Conical-shaped pits without scars and hardened tissue below. Red bug. (12)
3. Slight dimples or depressions, with a minute black speck in the center and with a thin line of hardened tissue leading thru the flesh to the core. Seed beneath contains a maggot. Apple-seed chalcid. (14)

E. Round red spots or flat scales. San José scale. (15)

F. Small cluster apples wrinkled at the calyx end. Rosy apple aphis. (16)

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* Numbers refer to paragraphs where further description of the injuries may be found.

1. CODLING MOTH.

The larva of this insect is by far the most destructive enemy of the apple and is the common cause of wormy fruit. There are two broods of the insect during the summer, and larvæ may be found at any time after the fruit is about three weeks old.

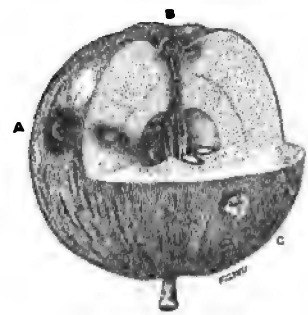

FIG. 1. CODLING MOTH.

Externally the injury appears as a small entrance hole of the young larva or as a large exit hole containing brownish excrement. (Fig. 1, A.) Entrance holes of the spring brood are usually in the calyx. (Fig. 1, B.) Late hatching individuals of the first brood and those of the second brood usually enter the side of the apple (Fig. 1, C), often in some scar or at the point of contact of two adjacent apples. These side injuries frequently show considerable shallow surface feeding or mining beneath the skin. Sometimes the larvæ die after entering the apple, so that a small surface cavity is the only injury present. Normally the interior of the apple shows a large feeding cavity in the core, partly filled with dark brown excrement.

Control.— The spraying made immediately after blossoming is directed into the blossoms so as to fill the calyx cups with arsenical poison before they close. A second spray is usually made two to four weeks later, and a summer spray is applied after the second brood moths are found emerging.

2. LESSER APPLE WORM.

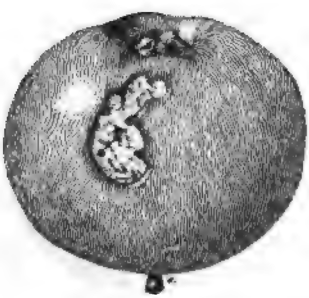

FIG. 2. LESSER APPLE WORM.

In most localities this insect does not occur in very large numbers. The first larvæ appear at about the same time as those of the codling moth, and in the North there are two generations annually.

Like the codling moth, many of the first brood larvæ enter the apple at the calyx, while later in the season more of them enter at the side. The burrows of the insect are made just beneath the skin of the apple and appear externally as irregular whitish mines. (Fig. 2.) The skin becomes wrinkled and often breaks open in places. The injury differs in appearance from the work of the apple maggot in being a single blotch instead of winding channels.

Control.— Methods used against the codling moth are applicable to this insect also.

3. APPLE MAGGOT.

This is another insect of minor importance in most localities. It attacks mainly summer and fall varieties of apple, and especially those which are sweet or sub-acid. The adult flies appear late in June or early in July and are present thruout the summer. Maggots may be found any time after the middle of July.

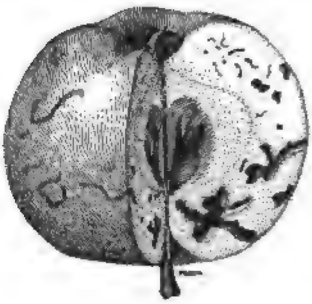

FIG. 3. APPLE MAGGOT.

The young maggots burrow long winding tunnels thru the flesh of the apple, and these increase in size as the larva grows. The pulp becomes riddled with holes and often decays. Many of the burrows run for some distance just beneath the skin and appear externally as dark winding streaks. (Fig. 3.)

Control.— A spray of lead arsenate (4 lbs. to 100 gals.) about the first week in July kills most of the flies before they deposit eggs. Another measure that is believed to reduce the number of the insects in the orchard is cultivation as ordinarily practised by commercial growers.

4. GREEN FRUIT WORMS.

There are several species of green caterpillars which appear in spring and feed upon the young leaves and fruit. Early in June they reach full size and pupate. The pests do not appear again until the following spring.

The larvæ attack the young fruit after it sets and eat large holes in the sides, often going as deep as the core. Many of the apples drop off, but if they are not too severely injured the wounds may heal over. When the fruit is mature the injury appears as a brownish scar, usually situated in a depression in the fruit. (Fig. 4.) The surface of the scar is slightly roughened and more or less covered with fine, corky scales, but does not bear the thick, corky coating which forms on wounds made later in the summer.

Control.— The sprays applied just before and after blossoming are the most important for the control of these insects.

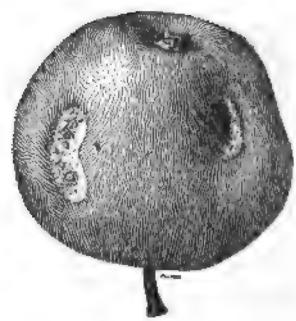

FIG. 4. EARLY APPLE WORMS.

5. FRUIT TREE LEAF-ROLLER.

The larvæ of this insect appear with the first apple leaves and pupate early in June. There is but a single brood annually. The

leaf-roller normally feeds more extensively on leaves, but when numerous it causes great destruction of the young fruit. Its work is similar to that of the green fruit worm but in general it may be said to cause greater distortion of the ripe apples by making deep holes in the very young fruit. (Fig. 4.)

Control.— The ordinary spraying practices do not give complete control when this insect becomes abundant. The eggs may be killed before the buds open by a spray of miscible oil and water (1–19) or by a ten-per-cent kerosene emulsion. The delayed dormant spray with lead arsenate added will aid in the control of this insect. If this is not sufficient, spray again with lead arsenate (6 lbs. to 100 gals.) when the blossom buds in the cluster begin to separate.

6. OTHER EARLY APPLE WORMS.

Altho the species of green fruit worms and the fruit tree leaf-roller are the most important insects which eat holes in the young fruit, there are many other leaf-feeding caterpillars, found on apple trees during May and early June, which occasionally produce the same kind of injury. Many of these are of rare or intermittent occurrence while others are present in small numbers nearly every year. Prominent among these are the palmer worm and the oblique-banded leaf-roller. The latter has two broods each year, the first of which is present at the same time with the single-brooded fruit-tree leaf-roller. The bud moth is known occasionally to eat holes in the young fruit in a manner similar to that of the leaf-roller and green fruit worm.

All wounds made when the apples are small, if not deep enough to cause the fruit to drop, will heal over later and form a new skin which will be of a pale brownish color with a slightly roughened surface and usually more or less covered with thin corky scales. (Fig. 4.) The latter are of dark brown color and are the remains of the original callus which formed soon after the wound was made.

7. ROSE CHAFER.

In sandy regions the adults of this insect often become suddenly abundant and cause great injury to crops within a very short time. There is but one brood of the beetles annually and in New York State they emerge about the middle of June. On account of the large size of the apples at this time the amount of deformation is only slight compared to the extent of the injury. The large irregular holes which the beetles excavate in the sides of the fruit do not heal over like wounds made early in the season, but form a thick corky callus, the surface of which often becomes cracked in the bottom of the cavity. (Fig. 5.) If the injuries are too extensive, as often happens when the beetles are numerous, rot starts around the holes and the apple drops.

Control.— Many methods have been used in an attempt to control this pest but most of them have been unsuccessful. Ordinary poison sprays fail to protect the plants, but sweetened arsenical sprays have sometimes given partial control. The formula for the latter is eight pounds of lead arsenate and two gallons of cheap molasses to one hundred gallons of water.

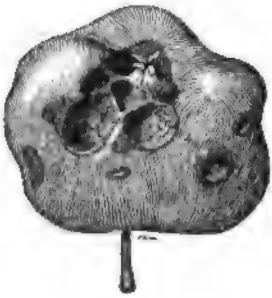

FIG. 5. ROSE CHAFER.

8. THE PLUM CURCULIO.

Altho more destructive to the stone fruits, this insect causes considerable damage to apples by disfiguring the surface with the feeding and oviposition punctures of the adults. The beetles appear in spring and continue their work from the time the fruit sets until the end of the summer.

As a result of the extended period of activity several kinds of injuries may appear on the ripe fruit. The earliest injuries then appear as brownish scars, usually semicircular in shape, often having a trace of a groove or depression on the straight side. (Fig. 6, A.) These result from the crescent shaped oviposition punctures which have become expanded due to the growth of the fruit. Early feeding punctures heal over and leave only light brown scars on the skin. (Fig. 6, B.) Late feeding punctures remain as permanent cavities in the surface. (Fig. 6, C.) The opening at the surface may be at first about one-sixteenth of an inch wide, but the cavity beneath has been enlarged by feeding beneath the skin as far as the beetle could reach with its beak. A section cut thru a feeding puncture reveals a more or less spherical cavity an eighth of an inch or more in diameter. A ring of dark brown discoloration forms about the opening which becomes enlarged due to drying of the skin.

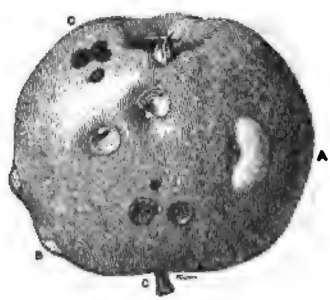

FIG. 6. PLUM CURCULIO.

Control.— The two sprayings given for the codling moth also help to control the plum curculio, but if the latter is very numerous additional applications of lead arsenate may be advisable. The best horticultural practices are found to be most unfavorable for the development of the curculios. Clean farming reduces the hibernating quarters of the beetles, and frequent shallow cultivation between July 10 and August 10 destroys many of the pupæ in the ground. Open, cultivated orchards are least infested with curculios because direct sunlight kills the larvæ in the fallen apples.

9. BUD MOTH.

Many of the opening buds of the apple are nearly destroyed by this insect, thus preventing blossoming and setting of fruit. Later it sometimes attacks the young apples. There is but one brood annually. The caterpillars, which hatch from the eggs in mid-summer, hibernate thru the winter and become full grown in June of the following year.

Early injury to the young fruit, if not great enough to cause it to fall, results in a scar similar in appearance to the work of the green fruit worm. The larvæ also feed on half-grown or mature fruit, beneath a leaf which they fasten down with web. This injury appears as surface feeding of small area or as minute holes and mines. (Fig. 7.)

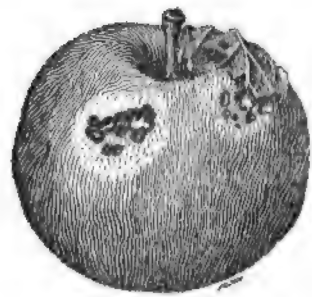

FIG. 7. BUD MOTH.

Control.— Three of the regular sprays carrying arsenate of lead help control this insect. These are the delayed dormant, blossom-pink and calyx applications.

10. CASEBEARERS.

There are two species of casebearers on apple, the cigar casebearer and the pistol casebearer. Both insects have but one brood a year. The casebearers usually feed on the leaves by making small mines in them, but they occasionally feed on the fruit both when young and later in the year. The work is similar to that on the leaves and consists of a small round hole with a shallow mine extending in all directions for a short distance. (Fig. 8.) The arsenical sprays used in the regular spraying schedule keep these insects under control. They seldom cause serious injury in well-regulated orchards in this region.

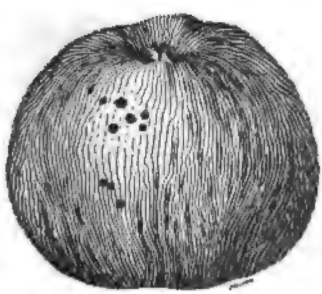

FIG. 8. CASEBEARERS.

11. LATE APPLE WORMS.

There are a number of caterpillars which appear on apple trees during the middle and latter part of the summer. Of these probably several species occasionally feed on the fruit. One is the second-brood of the oblique-banded leaf-roller. The caterpillar fastens a leaf to the fruit and feeds beneath it as does the bud moth. The injury appears as an irregular area of shallow surface feeding. The white-marked tussock-moth larvæ are also known to feed on apples occasionally during June and July.

Wounds made in apples when they are half grown or larger do not form a scar of pale brown new skin as in the case of the green fruit worm and other insects feeding in May and early June, but instead a dark, thick, corky callus forms over the exposed flesh of the fruit. If sufficient growth takes place later the callus will crack and reveal a paler brown surface beneath the dark brown scales. (Fig. 9, B.) When wounds are made in practically mature fruit a callus does not form but the surface of the flesh turns a brownish color and dries out or rots. (Fig. 9, A.)

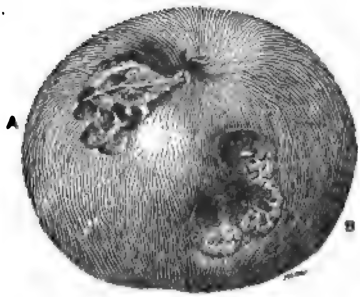

FIG. 9. LATE APPLE WORMS.

12. APPLE RED BUGS.

There are two species of apple red bugs which have very similar life histories and injure the fruit in the same manner. The bright red species hatches about blossoming time, while the darker one appears a little earlier, and both reach maturity and disappear late in June or early in July. There is but one generation each year. The presence of red bugs in an orchard may be detected early by the appearance of reddish-brown spots on the young leaves. Apples injured by the red bug bear shallow pits or dimples on the surface and if these are numerous the apple is considerably deformed. (Fig. 10.) The work can be distinguished from that of the plum and apple curculios by the fact that no scar is present in the center of the pit.

Control.— This is a difficult insect to control, but good results can be obtained by adding nicotine sulphate to the blossom-pink and calyx sprays. For the last few years the latter spray has been most effective, due to the greater prevalence of the later hatching species. For extreme infestations it may be advisable to give an extra drenching spray of nicotine sulphate, one pint to one hundred gallons of water, to which has been added four or five pounds of soap. A bright warm day is the best time for the application.

FIG. 10. APPLE RED BUG.

13. APPLE CURCULIO.

This insect breeds abundantly in wild crab and thorn apples, but is of much less importance in apple orchards than its relative, the plum curculio. The beetles appear and begin feeding and egg-

laying in the young fruit just after the blossoms drop, and continue the work until about the middle of July. The second brood of adults do little feeding but go into hibernation soon after emerging.

Externally the injury by the apple curculio appears usually as a deep conical depression with a small scar at the bottom. A section cut thru the center of the pit shows a thin hardened core leading toward the heart of the apple and terminating in a small cavity made by the long beak of the insect. (Fig. 11, B.) Occasionally the area around the puncture becomes elevated so that the pit appears as a crater-like hole at the summit. (Fig. 11, C.) Late oviposition cavities do not cause a deep pit to develop and are about one-eighth of an inch deep and half as wide, with a small opening at the surface. (Fig. 11, A.) Feeding punctures are much smaller.

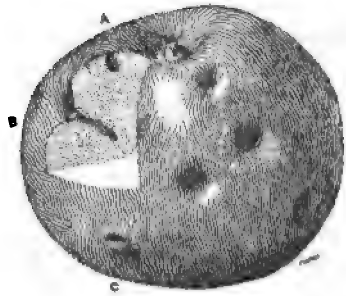

FIG. 11. APPLE CURCULIO.

Control.— The insects thrive only in crowded, uncultivated orchards, so that proper pruning and clean cultivation are the best preventive regulations. In case of an infestation by this insect the wild crab and thorn apples in the vicinity should be cut. The orchard should be cultivated and the infested apples which drop should be fed to stock or raked every few days into the sunlight, which is fatal to both larvæ and pupæ.

14. APPLE-SEED CHALCID.

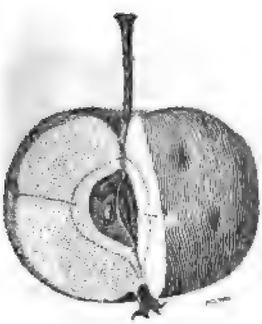
FIG. 12. APPLE-SEED CHALCID.

This insect is of little economic importance, since it affects the seeds more than the flesh of the apple and usually attacks only varieties that bear small fruits, and crab apples. The adults appear in June and deposit eggs in the seeds of the apples.

The only injury visible on the mature fruit is a small black dot often in the center of a shallow depression. A section cut thru black dot will reveal the effect of the ovipositor of the adult insect as a thin brownish line of hardened tissue extending to the core. (Fig. 12.) The seeds which contain maggots are flexible and generally of a pale color.

Control.— Because of the slight degree of injury caused, control measures are not necessary. If preventive measures are desired, a

complete destruction of all apples left under the tree in the fall would be effective, since the insects hibernate in the seeds.

15. San José Scale.

This well-known insect normally lives on the bark, but when abundant many of the larvæ wander to the fruit and leaves, where they settle down and form their scale covering. The young insects begin to hatch sometime between the middle of June and the middle of July, depending on the season, and continue to appear thruout the summer. On the fruit the scales have a tendency to cluster about the calyx and stem. A reddish discoloration of the skin forms about each insect as a circular spot, considerably wider than the scale itself. (Fig. 13.) When the fruit is badly infested the scales overlap and form a grayish scurfy deposit on the surface.

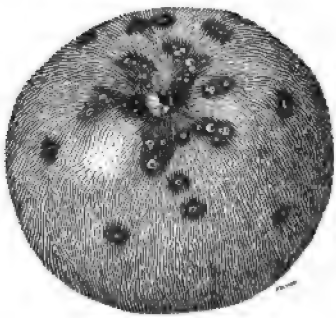

Fig. 13. San José Scale.

Control.— The standard remedy for San José scale is lime-sulphur, used while the trees are dormant or just as the buds show green at the tip.

16. Rosy Apple Aphis.

Altho the injurious work of this insect is confined to a couple of months in the spring, it has a much greater effect on development of the fruit than the green apple aphis which remains on the trees thruout the year. The rosy aphis hatches when the young leaves are beginning to appear at the tips of the buds, usually in the latter part of April, and the last of the winged females leave the trees in the latter part of June. A bad infestation of rosy aphis on a fruit spur, in some way not well understood, often causes all of the apples to set and the result is a cluster of small under-developed fruit. The characteristic cluster apple is compressed from pole to pole, the calyx end is slightly expanded and presents a broad, flattened area, while the portion immediately surrounding the calyx is much wrinkled and puckered. (Fig. 14.)

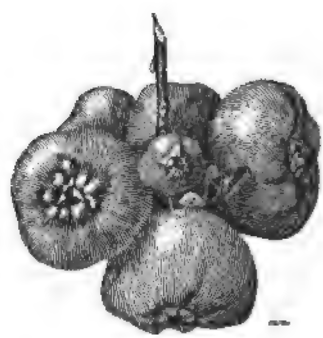

Fig. 14. Rosy Apple Aphis.

Control.— By delaying the dormant spray until the buds show green at the tip the newly-hatched aphids which congregate on them

can be killed by adding nicotine sulphate to lime-sulphur solution at winter strength. Care should be taken to spray all the buds thoroly.

Directions for Spraying Apples.

Most insects are so irregular in their occurrence that one cannot predict with any degree of certainty what year they are going to appear in injurious numbers. Under ordinary conditions it is advisable that the following spraying schedule be followed entirely each year so as to insure a good crop. Whenever the weather is hot and damp early in the season special precautions against scab are necessary and the time and number of sprays made after the calyx spray should be regulated accordingly. To determine the time of spraying for the second brood of codling moth a burlap band may be tied around a tree trunk to allow the larvæ to pupate under it. During the latter part of July this should be examined every few days, and when empty pupal cases are found within the newly formed cocoons it indicates that the moths have emerged and the time for spraying is at hand.

Spraying Schedule for Apple.

Period for Spraying.	Materials in Spray Mixtures.	Insects and Diseases Affected.
Delayed Dormant.	Lime-sulphur. (1–8, winter strength.)	Scale. Blister-mite.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Bud moth. Leaf rollers. Casebearers.
When buds show green at tips.	Nicotine sulphate, $\frac{3}{4}$ pint.	Aphids.
Blossom-Pink.	Lime-sulphur. (1–40, summer strength.)	Scab.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Green fruit worms. Bud moth. Leaf rollers. Casebearers.
When blossoms show pink.	Nicotine sulphate, 1 pint.	Dark apple red bug.
Calyx	Lime-sulphur. (1–40, summer strength.)	Scab.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Codling moth. Green fruit worms. Bud moth. Curculios. Lesser apple worm.
When last of petals are falling.	Nicotine sulphate, 1 pint.	Dark and bright apple red bugs.
Later sprays to be determined by weather conditions. Two sprayings often made are (1) two to four weeks after calyx spray, and (2) about the 1st of August, when the second brood of codling moth appears.	Lime-sulphur. (1–40, summer strength.)	Scab.
	To each 100 gallons add: Lead arsenate 4 to 6 lbs.	Codling moth. Curculios. Lesser apple worm. Apple maggot.

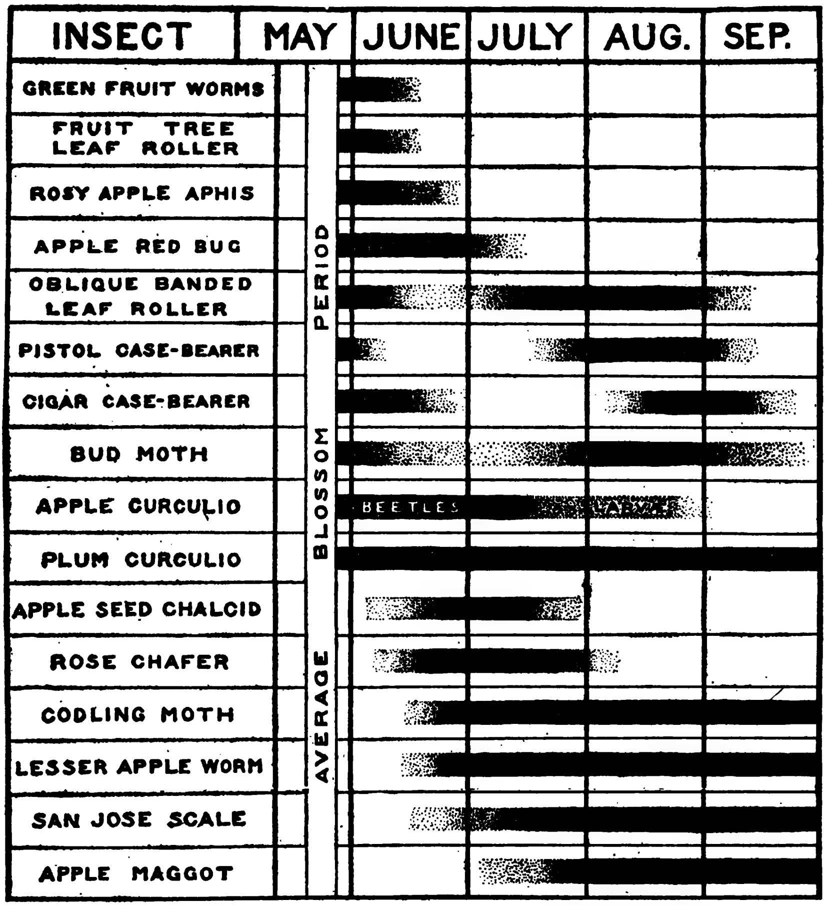

Table I.— Periods During Which the Insects are Actively Injurious to the Fruit But Not Necessarily the Proper Time for Combating Them.

LIME-SULPHUR MIXTURES.

BOILED LIME-SULPHUR WASH.

Lump lime	20 lbs.
Sulphur	15 lbs.
Water	50 gals.

Slake the lime with hot water and make a thin white-wash. Stir in the sulphur and boil one hour. Add water to make the required amount of wash and strain the wash thru a fine strainer into the spraying tank. Application should be made while the wash is warm. Flowers of sulphur, and light and heavy sulphur flour may be used. For the average orchardist this wash will give better results on scale than oil sprays, and the lime-sulphur mixture is especially recommended for the treatment of scale and leaf curl on peaches, the application being made as early as possible in the spring. Sulphur washes of this strength injure foliage and should only be applied to dormant trees.

HOME-MADE CONCENTRATED MIXTURE.

Lime	Pure CaO	36 lbs.
	If 95 per ct. pure	38 lbs.
	If 90 per ct. pure	40 lbs.
Sulphur, high grade, finely divided		80 lbs.
Water		50 gals.

The concentrated mixture is preferred by many fruit growers because of the convenience in handling it as compared with the above wash. The concentrated preparations are free from clogging sediment, may be used cold, are storable, and, therefore, available for use as convenient.

To make the concentrated mixture, place the lime in the container and start it to slaking with a small amount of water and then add the full amount. When the lime is about two-thirds slaked add the sulphur and stir frequently. Cook for three-quarters of an hour after the boiling point is reached. Enough water should be added to make fifty gallons. The mixture should be stored in barrels or other air-tight containers.

COMMERCIAL CONCENTRATED MIXTURE.

Many fruit growers prefer to buy commercial concentrated lime sulphur rather than go to the trouble of preparing it themselves. The concentrated preparations may usually be obtained from local dealers in spraying supplies. The mixtures usually test about 32 degrees Beaumé and are diluted one to eight for winter spray and one to forty for summer treatments of apples.

TESTING AND DILUTING CONCENTRATED LIME-SULPHUR.

The proportions of lime-sulphur and water used to make up the dormant and summer spraying mixtures depend on the strength of the concentrated solution. This can be tested with a Beaumé hydrometer, which is an instrument used for determining the weight and density of liquids. For use with lime-sulphur the hydrometer should be designed for heavy liquids testing as high as 35 degrees. The solutions should be tested when cold, and it is important to keep the hydrometer perfectly clean. After determining the density of the solution it should be diluted for spraying according to the table which follows:

DILUTION TABLE FOR LIME-SULPHUR WASH.

Density of solution in degrees Beaumé.	Dilution for delayed dormant spray. Proportions of lime-sulphur and water to make 100 gallons.		Dilution for summer sprays. Proportions of lime-sulphur and water to make 100 gallons.		Density of solution in degrees Beaumé.	Dilution for delayed dormant spray. Proportions of lime-sulphur and water to make 100 gallons.		Dilution for summer sprays. Proportions of lime-sulphur and water to make 100 gallons.	
	Lime-sulphur.	Water.	Lime-sulphur.	Water.		Lime-sulphur.	Water.	Lime-sulphur.	Water.
	Gals.	*Gals.*	*Gals.*	*Gals.*		*Gals.*	*Gals.*	*Gals.*	*Gals.*
36.....	10	90	2.2	97.8	25....	17	83	3.7	96.3
35.....	10¼	89¾	2.3	97.7	24....	18¼	81¾	4.	96.
34.....	10¾	89¼	2.4	97.6	23....	19½	80½	4.2	95.8
33.....	11¼	88¾	2.5	97.5	22....	20¾	79¼	4.5	95.5
32.....	11¾	88¼	2.6	97.4	21....	22¼	77¾	4.8	95.2
31.....	12¼	87¾	2.7	97.3	20....	23¾	76¼	5.2	94.8
30.....	13	87	2.8	97.2	19....	25½	74½	5.6	94.4
29.....	13½	86½	3.	97.	18....	27	73	6.	94.
28.....	14¼	85¾	3.1	96.9	17....	29	71	6.4	93.6
27.....	15	85	3.3	96.7	16....	31	69	6.8	93.2
26.....	16	84	3.5	96.5	15....	33¼	66¾	7.3	92.7

BENTLEY B. FULTON.

REPORT

OF THE

Department of Horticulture.

U. P. Hedrick, *Horticulturist.*

Roy D. Anthony, *Associate Horticulturist.*

O. M. Taylor, *Associate Horticulturist.*

†Geo. H. Howe, *Assistant Horticulturist.*

J. W. Wellington, *Assistant Horticulturist.*

Fred E. Gladwin, *Associate Horticulturist.*
(Connected with Grape Culture Investigations.)

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† On leave in war service.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

NEWER VARIETIES OF STRAWBERRIES.*

O. M. TAYLOR.

INTRODUCTION.

This report on strawberries sets forth the results of the tests of the introductions since the issue of Bulletin No. 401. The sixty-one varieties described do not include all that were grown. The standard commercial kinds have fruited each year and have been used as a basis of comparison. Cultural directions are omitted, as this subject is treated in detail in Circular No. 31. All varieties were grown in matted rows, and the selection of soil and the methods followed were as uniform as possible.

Source of varieties.— To avoid the possibility of reporting on plants not true to name the stock was obtained directly from the originator or introducer, if possible, and statements were secured from them in regard to the history of the variety. Past experience has shown that under such apparently favorable circumstances, errors occur and at times reports are received which are at variance with previous statements from the same persons. Plants of over fifty of the varieties came from originators or introducers. Definite statements were secured giving one or both parents of thirty-three varieties, while twenty-eight kinds are chance seedlings of unknown parentage.

Station seedlings.— During the past few years this Station has carried on extensive experiments in the breeding of fruits. The strawberry has not been neglected. Thousands of plants have been under observation. A few of these, after fruiting for several years, were considered worthy of more extended trial. In the spring of 1917 plants of eight kinds that had been named were distributed in different parts of the State for testing under varying soil and climatic conditions. It is not expected that they will all do as well elsewhere as on the Station grounds. After a thoro and extensive test, some of these seedlings may continue to make good records and if so several growers located thruout the State should have

* **Reprint of Bulletin No. 447, February, 1918.**

plants for sale. This Station has no more plants for distribution of these eight kinds. Full descriptions are included of these seedlings, all of which mature in early or late mid-season.

Plant-makers.— Over-crowding of plants is a common cause of unsatisfactory results. Some kinds like Angola, Frances Wiliard, Myrtle Murrell, Rewastico and Wildwood produce runners in such numbers that more distance should be given between rows and plants. Other varieties are shy plant-makers and if the ordinary distance is used, the ground is but poorly filled with plants and the yield is low altho the yield per plant may be high. The following twelve kinds have a tendency to produce comparatively few plants:

SHY PLANT PRODUCERS.

Addison	Benancie	*Minnesota No. 1017*
Advance	Friendship	Richmond
Alvin	Hustler	Standpat
Autumn King	J. B.	Todd

Plant-vigor.— Size of plant and sturdiness are relative terms and are influenced by character of soil, food-supply, temperature and rainfall, as well as by the variety itself. Among the strongest-growing kinds may be named Aurora, Edmund Wilson, Ford, *Morgan No. 21* and Wildwood.

Yield.— An unproductive variety is undesirable. Yield is a variable factor influenced by almost every condition of environment. Yet a variety, when all conditions appear ideal, may yield hundreds of quarts of fruit while some other variety under apparently identical conditions will produce thousands of quarts. During the past two years ample rainfall has prevented the usual reduction in yield by drought, but has caused losses at times by keeping foliage and fruit too wet, so it was impossible to remove the heavy yield in good condition. Seven varieties, Benancie, Joe Crampton, Jopp Favorite, Lady Corneille, Myrtle Murrell, Standpat and *Wittlinger No. 1* were uniformly unproductive, while the following nineteen kinds produced fruit in greatest abundance:

VERY PRODUCTIVE VARIETIES.

Allen No. 1	Eureka	Nellis Triumph
Angola	Ford	*Minnesota No. 3*
Athens	Friendship	*Minnesota No. 1017*
Chester	Gibson	Oregon
Collins	*Knight No. 1*	Rewastico
Eldorado	*Morgan No. 21*	Richmond
		Wildwood

Health.— Resistance to disease, when combined with other desirable qualities, is greatly to be desired. It is difficult to determine whether freedom from disease is an inherent quality or is due to lack of conditions which favor the spread of such troubles. Varieties may be healthy one season and show much disease a year later. Several years must elapse and the plants be grown under unfavorable conditions to determine their susceptibility to disease. During the period of this test the following ten varieties showed much injury from leaf-spot:

VARIETIES SUSCEPTIBLE TO LEAF-SPOT.

Alaska	Joe Crampton	Standpat
Charles I	McAlpine	Todd
Friendship	Myrtle Murrell	Warren
		Wildwood

Color of foliage.— Few varieties are characteristic in leaf-color. Rich soil and applications of stable manure or of nitrogenous fertilizers tènd to produce a dark green color while lack of nitrogen, as well as conditions of poor drainage, is liable to result in lighter color. The color of foliage appeared lightest in Friendship, McAlpine, Marshall Improved and Myrtle Murrell, the darkest color being represented in Ford, La Bon, Rewastico and Warren.

Sex of plants.— The present-day tendency is to give preference to perfect-flowering or staminate varieties, not because they are more productive or the fruit of higher quality but because it is thus unnecessary to provide other varieties to be used as pollenizers. Only twelve kinds described in this bulletin are imperfect-flowering, while nearly fifty varieties have both stamens and pistils. The twelve varieties referred to are as follows:

FLOWERS IMPERFECT OR PISTILLATE.

Addison	Angola	Kellogg Prize
Alden	Frances Willard	*Knight No. 1*
Allen No. 1	Hustler	*Morgan No. 21*
Alvin	J. B.	Todd

Season of bloom.— Blooming-periods of varieties usually receive little if any attention. It is useless, however, in localities subject to late frosts to attempt to use the varieties that bloom too early. Among the very earliest-blooming sorts are: Alvin, Campbell, Eureka and Wide-awake; sixteen other varieties bloomed early;

four varieties, Autumn King, Hustler, Jopp Favorite and Todd opened their flowers late and the latest of all were Ford and Pearl.

Fruit-stems.— Consideration of fruit-stems might seem at first of no importance, yet their length, thickness and position, have a bearing on the condition of the fruit at harvest time, and the widest variations may be found among the varieties. Conditions of growth, however, may modify the fruit-stems so that these characters are not entirely constant but vary somewhat with the season. Alaska, Alvin, Collins, Ford and *Morgan No. 21* produced very long fruit-stems while those of Charles I, Minnetonka, Premier and Standpat were very short; fruit-stems of Frances Willard, Pearl, Rewastico and Todd were very thick; those of Advance, Autumn King, Collins, Joe Crampton, McAlpine, Myrtle Murrell, Oregon, Standpat, Wide-awake and Wildwood were slender; nineteen varieties produced erect fruit-stems and twenty-three varieties semi-erect to prostrate.

Calyx-characters.— There are usually marked variations in size, position and color of the calyx among varieties, altho some kinds are quite variable in the berries of the same variety. Edmund Wilson, Ford and *Morgan No. 21* developed a calyx of largest size; varieties with a small calyx are represented by Alvin, Argyle, Ashton, Autumn King, Charles I, Eldorado, Standpat and Wide-awake. The position of the calyx is variable; sometimes it is perched on a distinct neck, at other times attached directly to the flat base of the berry, and in some varieties it is sunken deeply in the surface. The calyx of thirty-two varieties was more or less raised, while at least twelve kinds were characterized by the sunken calyx. Attractive appearance of calyx is desirable but here again there are variations, some being uniformly bright, attractive green, others dull, dingy green and at times disease destroys the naturally handsome color. Eleven varieties were noted for the dull, unattractive color of calyx.

Position of seeds.— The position of the seeds in relation to the surface of the berry is usually of but little concern to the strawberry grower, yet it is a character that should not be altogether ignored. They may be characteristically raised above the surface as in the case of Advance and of twenty-four other varieties or the seeds may be deeply sunken in the fleshy surface, as in the case of nineteen kinds. Raised seeds protect the surface from being bruised

and such berries usually ship well, altho in some varieties the numerous, raised seeds give an unattractive appearance, especially with the smaller berries.

Season of ripening.— The time of ripening referred to in this bulletin is the June and early July period and has nothing to do with the "fall-bearing" season, although several varieties are described which characteristically produce their fruit during the fall months. Such varieties were given the same cultural treatment as the other kinds, and this must be borne in mind in interpreting results.

The ripening-season is of great importance. In some localities only the earlier varieties are profitable while in other markets the demand is for late-ripening kinds. In this report the season has been divided into very early, medium early, early mid-season, late mid-season, late and very late. The seasons are overlapping and to make any sort of division, arbitrary dates must be fixed with but scant leeway between the close of one season and the beginning of the next.

VERY EARLY	MEDIUM EARLY	LATE	VERY LATE
Campbell	Advance	Alvin	Abundance
Eureka	Charles I	Autumn King	Ford
Richmond	Eldorado	Hustler	J. B.
	John H. Cook	Kellogg Prize	Joe Crampton
	La Bon	*Knight No. 1*	Jopp Favorite
	Lady Corneille	McAlpine	Pearl
	Marshall Improved	Rewastico	Todd
	Morgan No. 21		Warren
	Minnesota No. 3		Wildwood
	Oregon		
	Premier		
	Wide-awake		

Size of fruit.— Reasonable size is essential either for home use or for commercial purposes. It is dependent partly on the habit of the variety but is influenced largely by the amount of moisture available at ripening time. Berries may be too large as well as too small. Most varieties are intermediate in size. Addison, Ford, Jopp Favorite, Magic Gem, *Morgan No. 21* and Pearl produced fruit of largest size while at the other extreme were Minnetonka, Myrtle Murrell, Standpat and Wildwood. The following varieties retained good size fairly well thruout the season: Arcade, Argyle, Aurora, Charles I, Collins, Edmund Wilson, Frances Willard, Jopp Favorite, Magic Gem, Nellis Triumph, Oregon, Pearl, Warren. Most kinds dropped rapidly in size after the first two pickings.

Shape of fruit.— Shape of fruit is not usually of much concern in varieties of strawberries. There are a few, however, the fruit of which is often malformed or misshapen. Roundish-conic berries usually look better and pack to better advantage than those long or wedge-shaped. Over thirty of the varieties described were conic or roundish-conic; less than half a dozen were roundish; one, the La Bon, was inclined to be oblate; twenty-five kinds were slightly wedge-shaped; five kinds, *Allen No. 1*, Collins, Eureka, John H. Cook and Jopp Favorite were decidedly wedge-shaped; while the long-conic berries were represented by Alaska, Aurora, Frances Willard, Friendship, Greek, Myrtle Murrell, Premier, Richmond and Woodrow.

Color of fruit.— Undesirable color will disqualify any variety. The appearance must be fairly attractive. The berries may be light red, medium red or dark red yet be bright and glossy, giving a handsome appearance. A dull, dingy or faded color is undesirable whether the prevailing color be light or dark. The fruit of fourteen varieties was light red, about the same number medium red, with over a dozen dark red, the darkest of all being Wide-awake. Twenty varieties were dull.

Color of flesh.— The flesh-color depends on the variety and also to some extent on the stage of ripeness. Many berries with light red flesh, whitish at the center, become darker red thruout when fully mature, making it difficult to distinguish those which are characteristically whitish at the center. This character is noted in the description of varieties. Fifteen varieties produced whitish-centered berries, nearly thirty kinds medium to dark red, and twelve kinds light red.

Juiciness of flesh.— The relative amount of juice in the flesh is quite constant. No amount of external moisture will make up for a natural dryness of texture. A dry berry or one lacking in juiciness will continue to be dry, rain or shine. Ten varieties are characterized as very juicy, over thirty as juicy and more than a dozen are lacking in juiciness or are but medium juicy.

Firmness of berry.— Solidity of texture is of great importance. A soft berry is worthless for shipment to any distance no matter how desirable in size, color or flavor, altho this character is not so important for home use. It, however, is always desirable, for lack of firmness almost always results in a "mussy" condition of the

Plate XXV. —Addison.

Plate XXVII.—Arcade.

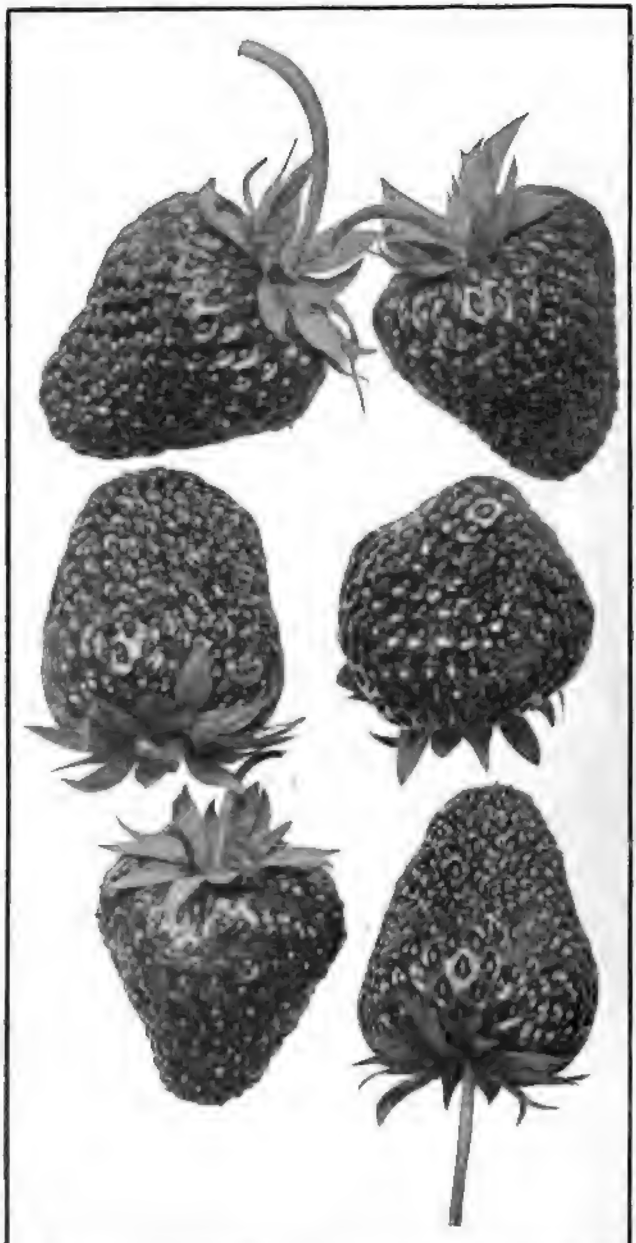

Plate XXVIII.— Aurora.

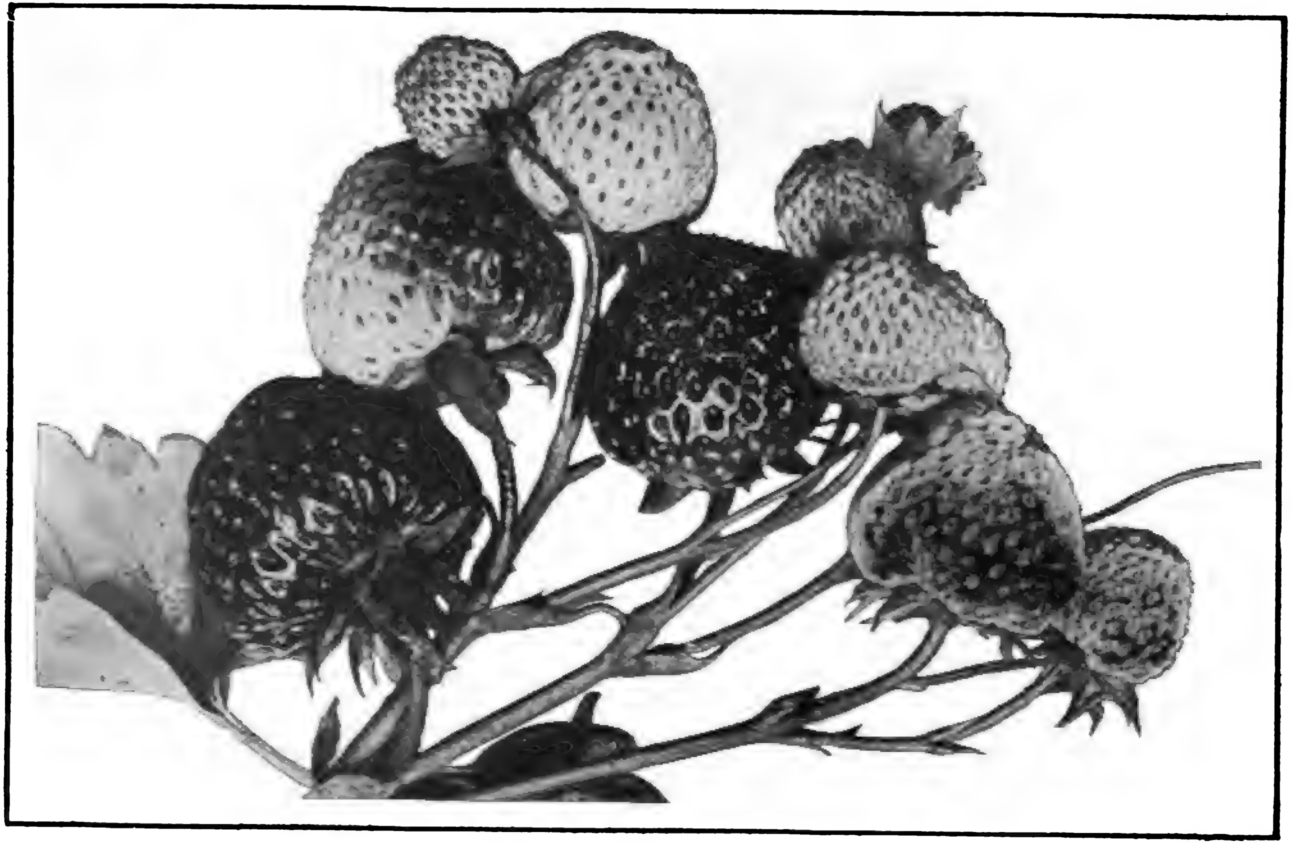

PLATE XXIX.— ALDEN.

Plate XXX.— Athens.

Plate XXXI.— Ashton.

Plate XXXII.— Argyle.

Plate XXXIII.— Ford.

fruit. Among the varieties under discussion, twenty-seven were rated as firm, fifteen as lacking more or less in firmness and the following ten varieties as very firm:

BERRIES VERY FIRM.

Allen No. 1	Magic Gem	*Minnesota No. 1017*
Chester	Minnetonka	Pearl
Greek	*Morgan No. 21*	Wide-awake
		Woodrow

Flavor.— One of the most difficult characters to determine is that of flavor. There is often more or less lack of uniformity in flavor between berries of the same variety, berries ripening in a dry or a wet period, the particular stage of ripeness reached and also a variation in personal likes and dislikes. What is pleasant to one palate may be quite disagreeable to another. There is, however, such a wide variation in flavors among the different varieties that some kind may be found acceptable to almost any palate. Over forty of the varieties may be designated as subacid or slightly sprightly while at the extremes are found seven varieties, Collins, Friendship, Greek, Lady Corneille, *Minnesota No. 1017*, Rewastico and Wide-awake distinctly tart and such varieties as Alaska, Argyle, Chester, Ford, *Knight No. 1*, Myrtle Murrell and *Wittlinger No. 1* among the list of those sweetest. Argyle, Gibson and Magic Gem are among the highest-flavored kinds.

Quality.— The most important rating is that of quality. By quality is meant the sum of all the characters that make the berries desirable to the taste. What varieties may be considered best or poorest in quality? Here again the personal element enters, for standards of judgment differ and what is good in the sight of one person may be moved either forward or backward by some other judge. Three varieties, Argyle, Magic Gem and *Morgan No. 21* were rated very good, over thirty varieties good, eighteen kinds fair and eight varieties distinctly poor.

Promising varieties.— In the determination of what varieties should be recommended for testing, all factors must be considered and each should receive its relative value. It must be remembered that all the varieties fruited on a heavy, cold, clay loam, which is not considered ideal soil for the strawberry. Doubtless on a lighter, warmer soil some of these varieties would have made a better record. All the most promising kinds have their defects as well as their good

points. The following list is therefore only suggestive of those varieties which have made the best showing for one or more years under the local climatic and soil-conditions at this Station. More than half the varieties are in the discard list. The eight seedlings originating at this Station are of course included among those of promise, leaving nine other kinds considered of merit, with eight varieties on the doubtful list, which on account of an unusually fine record along one or more important characters should be further tested despite certain defects.

DESIRABLE VARIETIES.

Addison
Alden
Angola
Arcade
Argyle
Ashton
Athens
Aurora
Campbell
Eldorado
(?) **Eureka**
Ford
(?) **Frances Willard**
Gibson
(?) **Hustler**
(?) **John H. Cook**
Joe (Joe Johnson)
(?) **Kellogg Prize**
Magic Gem
Morgan No. 21
(?) **Minnesota No. 3**
Oregon
Pearl
(?) **Warren**
(?) **Wide-awake**

DESCRIPTION OF VARIETIES.

The following descriptive notes indicate the behavior of the varieties at this Station. The most important characters of plant and fruit have been recorded. The address following the name of each variety gives the source of stock. The history of the variety has been obtained whenever possible from the originator or introducer. Following the description is a paragraph summarizing the comparative value of the variety.

Distribution of varieties.— This Station occasionally distributes seedlings originating here. These are sent only to growers who have opportunity to test them in comparison with other varieties and under such conditions as will make the work profitable to this Station. As a rule, the Station makes its own selection of such growers and there is little need of others to apply. Varieties sent here to be tested are under no circumstances permitted to be sent from the Station grounds.

Abundance.— (H. J. Schild, Ionia, Mich.) A seedling of Indiana originated by H. J. Schild in 1910 and introduced by Flansburgh & Son, Jackson, Mich., and J. T. Lovett, Little Silver, N. J., in 1916.

Plants numerous, of medium vigor, productive, healthy; leaves small, thick, dark green, rugose; flowers perfect, early mid-season, one and one-fourth inches across; petals roundish, six to seven in number; stamens numerous, long; receptacle large,

plump; fruit-stems short, thick, erect, branching; calyx large, much raised, leafy; seeds sunken. Fruit matures very late; intermediate in size, oval to blunt-conic, irregularly furrowed, sometimes wedge-shape, strongly necked, unattractive light red; apex obtuse, indented; flesh light red to the center, medium in juiciness and firmness, sprightly, not high-flavored; quality fair.

Plants somewhat low-growing, with attractive, dark green foliage among which are thickly intermingled the large, showy blooms. A berry not of large size, roughish in general appearance, not attractive in color, characteristically necked, too tart for most palates.

Addison.— (New York Agricultural Experiment Station, Geneva, N. Y.) Flowers of President were fertilized with pollen of Marshall by this Station in 1907; sent out for testing in the spring of 1917.

Plants medium to rather few in number, vigorous, very healthy, productive; leaves large, thick, dark green, rugose; flowers imperfect, open in early mid-season, somewhat small, averaging seven-eighths inch across; petals of medium size, roundish-ovate, six to eight in number; receptacle intermediate in size, roundish to wedge; fruit-stems medium to long, thick, semi-erect to prostrate, branching; calyx rather large, slightly raised, medium green; seeds often variable in position. Fruit matures in mid-season; very large to medium, conic to blunt-wedge, necked, very glossy, attractive medium red; apex obtuse, often indented; flesh red to the center when fully ripe, juicy, medium to firm, mild subacid; good in quality.

Plant-habits unusually good, especially in freedom from leaf-spot; makes more plants than its parent Marshall, yet does not produce runners in abundance; fruit of good size, altho variable, very glossy and usually somewhat necked, very attractive in appearance if not picked too early; greatest defect appears to be the tendency for the surface to bruise unless handled with care; a mild berry of good quality, worthy of trial.

Advance.— (Samuel Cooper, Delevan, N. Y.) A cross between Autumn and Cooper made in 1907 by Mr. Cooper and introduced by him in 1914. An "everbearer."

Plants few, medium in size, vigor and yield, healthy; leaves small, thick, glossy, dark green, smooth; flowers perfect, early, one and one-eighth inches across; petals roundish, five to six in number; stamens variable in number and length; receptacle small; fruit-stems short, slender, semi-erect to prostrate, usually single; calyx of medium size, flat or slightly raised; seeds prominent, much raised. Fruit matures early; medium in size, conic, not furrowed, often slightly necked, glossy, attractive medium red; apex somewhat pointed; flesh medium red thruout, moderately juicy, firm, very mild subacid, not high-flavored; fair in quality.

A poor plant-maker, with fruit characteristic in its glossy, plump surface and raised seeds; one of the best of shippers, attractive in color but disappointing in size and flavor; of the same type as Forward, Onward and Superb.

Alaska.— (T. C. Kevitt, Athenia, N. J.) Resulted from a cross of Climax with Glen Mary by T. C. Kevitt in 1913; not offered to the trade as yet.

Plants numerous, vigorous, medium in yield, injured by leaf-spot; leaves large, thick, dark green, glossy, rugose; flowers perfect, bloom early, one and one-fourth inches across; petals large, roundish, six to eight in number; stamens numerous, long; receptacle large, prominent; fruit-stems very long, medium in thickness, semi-erect to prostrate, branching; calyx large, unattractive in color, somewhat raised; seeds sunken. Fruit matures in mid-season; large to medium, irregular, long-conic to long-wedge, necked, glossy, attractive medium to dark red, often colors unevenly; apex a pointed wedge; flesh rather dark red, variable in color at the center, firm, medium juicy, mild, sweet; fair in quality.

Plants subject to disease, not very productive, producing fruit variable in size, unattractive in shape and color, many berries with a long, whitish or pale-red neck; undesirable.

Alden.— (New York Agricultural Experiment Station, Geneva, N. Y.) A cross between President and Marshall, made by this Station in 1907; introduced for testing in 1917.

Plants medium in number, large, productive, nearly free from leaf-spot; leaves large, thick, dark green, rugose; flowers imperfect, bloom in late mid-season, small, three-fourths inch across; petals small, broadly roundish, usually five in number; receptacle small, conic; fruit-stems long, variable in thickness, prostrate, branching; calyx large, usually flat altho sometimes slightly raised, leafy, with long, broad sepals; seeds variable in position. Fruit matures in mid-season; large, roundish-conic to broad-conic, sometimes slightly necked, variable in color but averaging a bright, glossy, medium red; apex blunt; flesh light red, becoming whitish toward the center, juicy, medium to firm, mild, pleasant flavored; of good quality.

Characters of plant desirable, developing a narrow, matted row, showing a small amount of leaf-spot; fruit of unusually good size, with an attractive calyx, nearly roundish, with a bright, glossy surface which is inclined to bruise easily unless handled with care; flesh somewhat variable in firmness and color, often whitish at the center, pleasant flavored; should be tested further.

Allen No. 1.— (W. F. Allen, Salisbury, Md.) A variety of unknown parentage found by Mr. Earnest Hurley, Salisbury, Md., about 1912, growing and fruiting in the woods near his house. The entire stock was purchased by Mr. Allen; not yet introduced.

Plants numerous, vigorous, healthy, very productive; leaves large, thick, dark green, rugose, glossy; flowers imperfect, bloom in late mid-season, less than one inch across; petals medium in size, often crinkly, roundish-ovate, five to seven in number; receptacle medium in size; fruit-stems long, thick, erect, branching; calyx medium in size, flattened, dull green; seeds sunken. Fruit matures rather late; above medium in size, irregular wedge, furrowed, slightly necked, dull, unattractive dark red; apex blunt, indented; flesh dark red, very firm, juicy, mild, not high-flavored; inferior in quality.

An imperfect-flowering variety with good plant-habits but deficient in color of fruit and lacking in flavor and quality.

Alvin.— (Louis Hubach, Judsonia, Ark.) A seedling, secured by Mr. Hubach by crossing Klondike with Climax in 1908; introduced by him in 1912.

Plants few in number, intermediate in size and vigor, healthy, productive; leaves large, of medium thickness, dark green, smooth; flowers imperfect, bloom very early, one inch across; petals roundish, overlapping, seven to eight in number; receptacle medium in size, conic; fruit-stems very long, of medium thickness, erect, becoming prostrate with the weight of fruit, branching; calyx small, depressed often discolored; seeds sunken. Fruit matures in mid-season; large, dropping in size rapidly as the season advances, wedge to roundish-conic, the largest berries often double, dull, unattractive light red; apex obtuse; flesh variable in color, very juicy, medium in firmness, sprightly, unpleasant flavor; poor in quality.

Characteristic at blooming-time with the long, upright, much-branched blossom-stalks; a light red berry, variable in size, shipping poorly and low in quality.

Angola.— (New York Agricultural Experiment Station, Geneva, N. Y.) In 1907 this Station crossed President with Marshall. One of the resulting seedlings was named Angola and in 1917 plants were sent out for testing.

Plants very numerous, vigorous, healthy, very productive; leaves intermediate in size, thickness and color, somewhat rugose; flowers imperfect, blossom in late mid-season, one inch across; petals of medium size, roundish, five to eight in number; fruit-stems long, thick, prostrate, single; calyx of medium size, flat; seeds somewhat raised. Fruit matures in mid-season; very large to medium, the largest berries with roughish surface, roundish-conic to blunt-wedge, glossy, attractive, medium to light red; apex very obtuse; flesh light red, sometimes whitish toward the center, very juicy, intermediate in firmness, slightly sprightly; good in quality.

An imperfect-flowering variety, producing plants in great numbers; berries among the largest of the Station seedlings, retain size well during the season, unusually attractive in their bright, glossy, red color; must be handled with care to avoid bruising the surface; worthy of test.

Arcade.— (New York Agricultural Experiment Station, Geneva, N. Y.) Flowers of President were fertilized by this Station in 1907 with pollen from Marshall. Among the resulting seedlings, one of promise was named Arcade and was distributed for testing in 1917.

Plants medium in number, vigorous, productive, variable in health; leaves large, thick, medium green, rugose; flowers perfect, open in early mid-season, one and one-fourth inches across; petals large, broadly roundish, six to eight in number; stamens numerous, above medium in length; receptacle intermediate in size, conic; fruit-stems long, thick, semi-erect, branching; calyx medium in size, flat or slightly raised, with long, rather broad sepals; seeds even or slightly raised. Fruit matures in mid-season; large, retains size well during the season, conic to slightly wedge, often necked, attractive, glossy, medium red; apex somewhat pointed; flesh light red, sometimes whitish towards the center, very juicy, rather firm, pleasant flavored, somewhat sprightly; of good quality.

Plants have been under test for several years and have been uniformly healthy except in 1917 when they were injured by leaf-spot; surface firmer and making a better shipper than some of the other seedlings of this Station; worthy of test on account of attractiveness in size, shape, color and desirable flesh-characters.

Argyle.— (New York Agricultural Experiment Station, Geneva, N. Y.) A seedling of President crossed with Marshall, in 1907 by this Station; introduced for testing in 1917.

Plants intermediate in number, vigorous, healthy, productive; leaves of medium size, thick, dark green, glossy, rugose; flowers perfect, bloom in early mid-season, one and one-eighth inches across; petals of medium size, roundish-ovate, five to eight in number; stamens variable in number, short; receptacle medium in size, roundish-conic; fruit-stems medium to long, intermediate in thickness, semi-erect to prostrate, single; calyx small, depressed or flattened; seeds even or slightly raised. Fruit matures in mid-season; above medium to very large, roundish-conic, the largest berries irregularly furrowed, glossy, attractive medium to dark red; apex obtuse; flesh light red, sometimes whitish towards the center, juicy, firm, mild, sweet, high-flavored; very good for a mild berry.

A perfect-flowering, mid-season variety with good plant-habits; berries of largest size, good flavor and quality, ship well, must be picked with care to secure uniform color; worthy of test for a mild berry of high quality.

Ashton.— (New York Agricultural Experiment Station, Geneva, N. Y.) This Station, in 1907 made a cross between President and Marshall. One of the most promising seedlings was named Ashton and was sent out for testing in the spring of 1917.

Plants intermediate in number, vigorous, healthy, productive; leaves large, thick, very glossy, dark green, nearly smooth; flowers perfect, appear in early mid-season, one and three-eighths inches across; petals large, roundish-ovate, five to seven in number; stamens numerous, above medium in length; receptacle of medium size, conic; fruit-stems short to medium, thick, semi-erect to erect, single; calyx small, depressed; seeds prominent, raised. Fruit matures in early mid-season; large, roundish-conic, surface of the largest berries irregularly furrowed, glossy, attractive medium to dark red; apex obtuse; flesh variable in color, juicy, firm, somewhat sprightly; good in quality.

Resembles Argyle closely in size of fruit, color and shape but the calyx is slightly more sunken, the seeds more raised and the flesh more sprightly; on the Station soil, held its own with the best commercial varieties.

Athens.— (New York Agricultural Experiment Station, Geneva, N. Y.) A cross between President and Marshall, made by this Station in 1907; introduced for testing in the spring of 1917.

Plants medium in number, vigorous, usually healthy, very productive; leaves intermediate in size, thick, dark green, rugose; flowers perfect, bloom in early mid-season, one inch across; petals below medium in size, roundish; fruit-stems medium to long, thick, semi-erect, branching; calyx medium in size, variable in position,

with short, broad sepals; seeds usually sunken altho variable. Fruit matures in mid-season; large, dropping in size as the season advances, irregular-wedge to irregular-conic, the largest berries furrowed, usually necked, bright red to darker red depending on stage of maturity, glossy, attractive; apex variable in shape; flesh not uniform in color, very juicy, firm, pleasant flavored, sprightly; good in quality.

Plants very desirable in habit except for an attack during one year of leaf-spot; unusually good in size, somewhat variable in color depending on stage of ripeness; a sprightly berry, pleasant flavored, dropping in size as the season advances; the bright red color is most attractive both in the fresh fruit and in the canned product; should be tested further.

Aurora.— (New York Agricultural Experiment Station, Geneva, N. Y.) A pure seedling of Prolific started in 1907 by this Station and introduced as worthy of test in the spring of 1917.

Plants numerous, very vigorous, somewhat injured by leaf-spot under unfavorable conditions, medium in yield; leaves large, of medium thickness, dark green, nearly smooth; flowers perfect, bloom in late mid-season, one inch across; petals of medium size, broadly ovate, six to eight in number; stamens medium in number, short; receptacle intermediate in size, roundish to wedge; fruit-stems rather short, thick, semi-erect, branching; calyx large, flat, leafy, attractive green; seeds usually sunken. Fruit matures in late mid-season; large, retains size well during the season, symmetrical, long-conic to long-wedge, usually not necked, glossy, attractive medium red, colors evenly; apex pointed; flesh well colored, juicy, firm, agreeably sprightly; good in quality.

Habits of plant desirable except that under unfavorable conditions the foliage may be injured by leaf-spot; the latest blooming of the eight Station seedlings described in this bulletin; a bright red, long-conic berry usually with pointed apex, shipping well; flesh sprightly and of good flavor; should receive a more extended trial.

Autumn King.— (E. W. Townsend, Salisbury, Md.) Secured in 1911 by Mr. Townsend by crossing Autumn with Chesapeake and introduced by him in 1914; an "everbearer."

Plants very few, medium in vigor and yield, healthy; leaves small, thick, dark green, rugose; flowers perfect, small, usually less than one inch across, bloom late; petals roundish, six to seven in number; stamens numerous, short; receptacle of medium size, blunt-conic; fruit-stems short, slender, prostrate, single; calyx small, raised; seeds usually raised, prominent. Fruit matures late; medium in size, conic, sometimes faintly and irregularly furrowed, necked, variable in color, glossy; flesh red thruout, medium juicy, firm, mild subacid, not high flavor; inferior in quality.

Almost no runners developed from the plants. The fruit, as compared with June-fruiting varieties was easily surpassed both in size and quality.

Benancie.— (Louis Hubach, Judsonia, Ark.) A cross of H & H with Climax made by Mr. Hubach in 1908; introduced by him in the spring of 1912.

Plants few in number, intermediate in size and vigor, healthy, unproductive; leaves variable in size, thick, medium green, rugose; flowers perfect, bloom early, one and one-eighth inches across; petals roundish, six to eight in number; stamens medium in number; receptacle of average size, roundish; fruit-stems rather short, thick, semi-erect, single; calyx large, flattened, leafy; seeds prominent, raised. Fruit matures in mid-season; medium in size, wedge to blunt-conic, glossy, attractive dark red; apex variable in shape; flesh dark red thruout, juicy, firm, decidedly sprightly; of good quality.

An early-blooming variety producing but few plants which are unproductive; a dark red, tart berry, somewhat seedy in appearance, inferior in size, an unusually good shipper, surpassed in value by other varieties of its season.

Campbell.— (W. B. Kille, Swedesboro, N. J.) A seedling of unknown parentage, originating with James Campbell, Newport, N. J., in 1910; introduced by Mr. Kille in 1916.

Plants medium in number and vigor, healthy, productive; leaves intermediate in size and thickness, dark green, rugose; flowers perfect, open very early, one and

one-fourth inches across; petals of medium size, six to eight in number; stamens numerous, long; receptacle prominent, roundish; fruit-stems short, thick, prostrate, double; calyx medium in size, flat or slightly raised; seeds sunken. Fruit matures very early; of good size in the first two pickings, later dropping rapidly in size, wedge to conic, the smaller berries slightly necked, variable in color and glossiness; apex a blunt-wedge; flesh light red, variable color at the center, juicy, firm, subacid or pleasantly sprightly; good when fully ripe.

The earliest to ripen in 1917; one of the most productive of the early varieties; plant-habits good; two heavy picks before Dunlap ripens, after which the size is disappointing and color becomes dingy; pleasant flavor and high quality most pronounced in the fully ripe fruit, the lighter berries whitish at the center; flowers open too early in localities subject to frosts, the earliest of the sixty-one varieties described in this bulletin; in spite of its defects, worthy of test on account of earliness and high quality.

Charles I.— (O. A. D. Baldwin, Bridgman, Mich.) A chance seedling found in the woods about 1905 by George Hann, Bridgman, Mich.; introduced by Mr. Baldwin in 1911.

Plants numerous, medium in vigor, severely attacked by leaf-spot, productive; leaves small, thin, medium green, rugose; flowers perfect, early, one inch across; petals medium in size, roundish-oval, five to eight in number; stamens numerous, long; receptacle small; fruit-stems very short, thick, much prostrate; calyx small, flat, dingy green; seeds sunken. Fruit matures medium early; large, retains size well during the season, very blunt-conic, characteristically light red, dull, unattractive; apex much obtuse; flesh whitish toward the center, juicy, lacking in firmness, mild, not high-flavored; inferior in quality.

Plants altho productive are subject to disease; berries of good size and shape but are too soft for a desirable shipper, unattractive in color and lacking in flesh-characters.

Chester.— (W. S. Todd, Greenwood, Del.) A chance seedling of unknown parentage found in a yard in Chester, Pa., in 1912. Plants were sold locally in 1915.

Plants intermediate in number and vigor, healthy, very productive; leaves small, of medium thickness, dark green, rugose, glossy; flowers perfect, bloom in late mid-season, one and one-eighth inches across; petals large, roundish, five to seven in number; stamens numerous, variable in length; receptacle of medium size, roundish-conic to wedge; fruit-stems intermediate in length, thick, erect, branching; calyx large, leafy, flat or depressed, attractive green; seeds raised. Fruit matures in mid-season; large, irregular roundish to almost oblate, much furrowed, medium to dark red, not very attractive; apex indented, green-tipped and seedy; flesh rather dark red, medium juicy, very firm, often hollow at the core, sweet, mild; good in quality.

A very productive, healthy variety, fruit of which is fig-like in type, of desirable size and quality as well as one of the best of shippers but the surface is strongly furrowed and the apex too often mal-formed and seedy to make a pleasing appearance.

Collins.— (C. E. Whitten, Bridgman, Mich.) Thought to be a cross between Beder Wood and Pocomoke, the seed of which was sown in 1910 by C. H. Collins, Bridgman, Mich.; introduced in the spring of 1915 by Mr. Whitten.

Plants numerous, vigorous, nearly free from leaf-spot, very productive; leaves large, thin, dark green, smooth; flowers perfect, appear in late mid-season, one inch or less across; petals small, obovate, five to seven in number; stamens numerous, long; receptacle small; fruit-stems very long, slender, prostrate, single; calyx of medium size, tinged red, strongly raised, with sepals much reflexed; seeds variable in position. Fruit matures in mid-season; large, retains size well during the season, furrowed, wedge-shape, strongly necked, attractive, glossy, medium to light red, coloring somewhat unevenly; apex pointed, often green-tipped; flesh medium red, juicy, firm, almost tart, with an unpleasant flavor; fair in quality.

Plant-habits unusually good, especially in yield; a mid-season variety, a splendid shipper, unusually attractive in size, shape and color but unfortunately on the soil at this Station the flavor is decidedly tart and the quality not of the highest.

Dr. Burrill.— (R. M. Kellogg Co., Three Rivers, Mich.) Blossoms of Crescent were fertilized with pollen from flowers of Dunlap by J. A. Reasoner, Urbana, Ills. One of the resulting seedlings was named Dr. Burrill; introduced by the Kellogg Co. in 1916.

Plants numerous, intermediate in vigor, healthy, productive; leaves of medium size, thickness and color, rugose, glossy; flowers perfect, open in early mid-season, one and one-eighth inches across; petals small, roundish, five to eight in number; stamens medium in number and length; receptacle small, conical; fruit-stems intermediate in length and thickness, semi-erect, branching; calyx of medium size, distinctly raised, with reflexed sepals, attractive green; seeds sunken. Fruit matures in late mid-season; large, regular, conical to slightly wedge, strongly necked, medium to dark red, glossy; apex pointed; flesh medium red thruout, variable in juiciness and flavor, firm, averaging subacid; fair to good in quality.

A perfect-blooming variety of good plant-habits, ripening in late mid-season; berries excellent in size, color and shape, type of Dunlap, but milder and disappointing in both flavor and quality.

Edmund Wilson.— (J. T. Lovett, Little Silver, N. J.) One of Dr. Van Fleet's seedlings of unknown parentage; originated in 1907; introduced by Mr. Lovett in 1913.

Plants numerous, very vigorous, healthy, productive; leaves characteristically large and dark green, medium in thickness, rugose; flowers perfect, bloom early, very large, often nearly two inches across; petals roundish, crinkly, five to eight in number; stamens intermediate in number and length; receptacle large, prominent; fruit-stems rather short, thick, semi-erect to prostrate, single; calyx of largest size, leafy, depressed; seeds usually sunken. Fruit matures in mid-season; large, retains size well to close of season, irregular-conic, broad at the base, variable in glossiness, dark red; apex obtuse; flesh dark red thruout, medium juicy, firm, mild subacid; fair in quality.

Plants characteristic in their large leaves, dark green color and in the pleasing appearance of the unusually large blossoms thickly interspersed among the foliage; altho the fruit is of good size, the color is often dull, the calyx detracts from the appearance and the flesh is inferior in flavor and quality.

Eldorado.— (King Bros. Nursery, Dansville, N. Y.) Plants of this variety were sent to the Station for testing in the spring of 1916 by the King Brothers. Its origin seems to be obscure; said to have been introduced from Kansas.

Plants numerous, vigorous, healthy, very productive; leaves above medium in size and thickness, smooth, very glossy, medium green; flowers semi-perfect to perfect, bloom early, one inch across; petals small, roundish, six to eight in number; stamens medium to numerous, long; receptacle large, prominent; fruit-stems of medium length, variable in thickness, prostrate, branching; calyx small, flat, attractive green; seed variable altho mostly raised. Fruit matures medium early; large, irregular shape varying from roundish to very blunt-conic or wedge, broad at the base, medium to light red, somewhat glossy; apex very obtuse, indented; flesh whitish toward the center, juicy, firm, mild subacid, pleasant flavor; good in quality.

An early-blooming variety of excellent plant-habits, very productive for an early-ripening kind; berries of good size which is retained thruout the season better than the attractiveness of color, milder and sweeter than Dunlap; altho the color is rather dull toward the close of the season, the earlier pickings are much above the average and the variety is therefore considered worthy of further test.

Eureka.— (Louis Hubach, Judsonia, Ark.) Originated in 1910 with Mr. Hubach by crossing one of his unnamed seedlings with Klondike; introduced by him in 1912.

Plants intermediate in number, size and vigor, healthy, very productive; leaves small, thick, medium to dark green, nearly smooth; flowers perfect, bloom very early, one and one-half inches across; petals broad-oval, seven to eight in number; stamens numerous, long; fruit-stems short, thick, erect, branching; receptacle medium in size, blunt; calyx intermediate in size, depressed; seeds sunken. Fruit matures very early;

large to medium, slightly furrowed, wedge-shape, glossy, dark red; apex obtuse; flesh dark red to the center, juicy, firm, often hollow at the core, sprightly; good in quality.

May possibly have value on account of extreme earliness. The berries give indications of considerable value but unfortunately the crop was seriously injured by frost and drought so that the berries showed defects from such causes; requires further testing to determine its value.

Ford.— (E. W. Townsend, Salisbury, Md.) A chance seedling found growing wild by Mr. Granvill Brewington about 1913 in Wicomico County, Md.; introduced by Mr. Townsend in 1916.

Plants numerous, extremely vigorous, healthy, very productive; leaves of largest size, very thick, markedly dark green, rugose; flowers semi-perfect to perfect, bloom very late, one and one-half inches across; petals large, roundish, six to seven in number; stamens variable in number and length; receptacle of medium size; fruit-stems very long, thick, erect, branching into many long pedicels; calyx unusually large, flat, very leafy, attractive green, with long and broad sepals; seeds variable in position. Fruit matures very late; of largest size, regular, blunt-wedge to blunt-conic, attractive, glossy, medium to dark red, coloring somewhat unevenly; apex obtuse; flesh red thruout, unusually juicy, firm, mild, sweet; of good quality.

One of the best of the late varieties. A characteristic variety in its large, dark green leaves, large blossoms, long, erect and branching fruit-stems, size of calyx, as well as in the size and juiciness of the fruit; color somewhat variable yet attractive; surface bruises unless handled with care; retains size well thruout the season; the lateness of bloom is an asset in localities subject to late frosts; worthy of extended trial.

Forward.— (Samuel Cooper, Delevan, N. Y.) A seedling of Autumn crossed with Cooper in 1907 by Mr. Cooper; introduced by him in 1914. An "everbearer."

This variety is so similar in both plant- and fruit-habits to Advance that one description will answer for both varieties. See Advance for description.

Frances Willard.— (M. Crawford Company, Cuyahoga Falls, Ohio.) Seeds from an unnamed seedling were sown in 1910 by D. J. Miller, Millersburg, Ohio. One of the resulting plants was named Frances Willard and in 1914 was introduced by the Crawford Company.

Plants very numerous, vigorous, healthy, very productive; leaves unusually large, thick, dark green, rugose; flowers imperfect, open in mid-season, one inch across; petals broad-oval, five to seven in number; receptacle large, conic; fruit-stems rather long, very thick, semi-erect to prostrate, usually single; calyx medium to large, strongly raised; seeds variable in position. Fruit matures in late mid-season; large, retains size well during the season, long-conic to long-wedge, much necked, medium attractive, slightly glossy, rather light red; apex pointed; flesh light red to the center, medium juicy, firm, mild subacid; fair to probably good.

Plant-habits unusually good; fruit characterized by being strongly necked, long shape, excellent size, attractive externally but unfortunately the flesh-characters are disappointing; not very juicy, very mild, not high flavor; would make a good show berry — but would compare unfavorably with high-quality berries such as Marshall.

Friendship.— (J. F. Nickerson, Chatham, Mass.) Said to be a seedling of the Corsican found by Mr. Nickerson; not yet introduced.

Plants rather few, intermediate in vigor, injured by leaf-spot, very productive; leaves large, thin, light green, nearly smooth; flowers perfect, one inch or less across, open in early mid-season; petals very small, often greenish-white, broadly roundish, seven to nine in number; stamens numerous, long; fruit-stems short, thick, prostrate, single; receptacle large, roundish; calyx of medium size, raised, with long and narrow sepals; seeds slightly sunken. Fruit matures in mid-season; variable in size, long-wedge to long-conic, strongly necked, medium to light red, dull; apex pointed, flesh medium red to the center, juicy, moderately firm, tart, not pleasant flavor; poor in quality.

Altho very productive, the plants appear subject to disease and the fruit is disappointing in size and flesh-characters.

Gibson.— (David Knight & Son, Sawyer, Mich.) Thought by some to have come from Berrien County, Mich., but the origin and parentage appears to be obscure; catalogued in 1911 by Knight & Son. This variety is said to be distinct from the Gibson of New York. It is considered by some very similar to Parson Beauty and Pocomoke.

Plants rather numerous, of medium vigor, with but a trace of leaf-spot, very productive; leaves intermediate in size and thickness, dark green, slightly rugose; flowers perfect, large, nearly one and one-half inches across, crinkly, bloom early; petals large, broadly roundish, seven to nine in number; stamens numerous, long; fruit-stems of medium length, thick, semi-erect, single; receptacle large, roundish; calyx rather large, raised, leafy; seeds slightly sunken. Fruit matures in mid-season; above medium in size, blunt-wedge to conic, necked, attractive medium to light red; apex often pointed; flesh light red, juicy, firm, pleasantly sprightly, high-flavored; of good quality.

Plant-habits unusually good; a mid-season variety, with fruit of good color and fairly good size, a fine shipper, pleasing in its sprightliness, altho at the last it loses somewhat both in color and size; worthy of test for a commercial berry.

Greek.— (L. J. Farmer, Pulaski, N. Y.) Said to have originated with Sylvester Marshall, Athens, Ohio, in 1912; introduced in the spring of 1916 by Mr. Farmer.

Plants intermediate in number and vigor, healthy, productive; leaves of medium size, thickness and color, rugose; blossoms perfect, appear in early mid-season, one and one-eighth inches across; petals roundish-ovate, five to eight in number; stamens numerous, intermediate in length; receptacle of average size, roundish; fruit-stems above medium in length, semi-erect, branching into long pedicels; calyx large, distinctly raised and with long, reflexed sepals, tinged red; seeds raised. Fruit matures in mid-season; above medium in size, long-conic, almost oblong, strongly necked, attractive, glossy, medium red; apex pointed; flesh red to the center, juicy, very firm, tart or sprightly; fair in quality.

One of the best shippers of all the varieties and of handsome color; shape objectionable, and flesh too tart for most palates.

Hustler.— (W. F. Allen, Salisbury, Md.) A seedling of unknown parentage found in 1910 by R. P. Lovett, Fallsington, Pa.; introduced in the spring of 1915 by Mr. Allen.

Plants very few in number, of medium vigor, healthy, productive if planted closely; leaves medium to large, thin, intermediate in color; flowers imperfect, bloom late, one inch or more in diameter; petals of medium size, roundish, six to seven in number; pistils tinged red; receptacle large, prominent; fruit-stems short, thick, prostrate, branching; calyx large, raised, leafy; seeds raised. Fruit matures in mid-season; large, dropping in size as the season advances, roundish-conic, necked, attractive, medium red; apex very obtuse; flesh red thruout, medium in juiciness and firmness, pleasantly sprightly; good in quality.

An imperfect-flowering, mid-season variety developing but few runners and must be planted closely to secure a large yield; berries altho dropping in size as the season advances, are attractive in color, a good shipper, the raised seeds on the smaller berries detracting somewhat from appearance; distinctly necked; may have value to those who prefer a sprightly berry.

J. B.— (Louis Hubach, Judsonia, Ark.) A cross between Nettie and Aroma originating with Mr. Hubach in 1909; not introduced.

Plants few in number, medium in vigor, healthy, productive; leaves intermediate in size, thick, dark green, rugose; flowers imperfect, bloom early, small, less than one inch across; petals roundish, seven to nine in number; fruit-stems of medium length and thickness, erect, branching; receptacle very large, long-conic; calyx medium in size, flat to raised; seeds variable in position. Fruit matures very late; above medium in size, irregular-wedge to conic, furrowed, usually necked, attractive medium red; apex pointed; flesh red to the center, juicy, medium firm, pleasantly sprightly; good to very good in quality.

A berry of fairly good size, slightly dull in general appearance especially in the later pickings, but with desirable flesh-characters. Not equal to the best varieties of its season.

John H. Cook.— (J. T. Lovett, Little Silver, N. J.) One of Dr. Van Fleet's seedlings of unknown parentage grown by him in 1908; introduced by Mr. Lovett in 1915.

Not enough plants for a satisfactory test. So far as could be determined, the variety is perfect-flowering, blooming in mid-season, maturing its fruit medium early. The small amount of fruit available for test was of large size, attractive, glossy, dark red, wedge-shape, mild, pleasant subacid, and good quality. The variety may possess considerable value but it requires further testing to determine its standing.

Joe Johnson.— (E. W. Townsend, Salisbury, Md.) As fruited at this Station, there appears to be but minor differences if any from the Big Joe or Joe — fully described in previous bulletins as a perfect-flowering, late or late mid-season variety having many qualities to commend it, especially large size of fruit, attractive color and desirable flavor and quality. Reports from other states also indicate that this is the " Joe."

Joe Crampton.— (Daniel Lock, Union Pier, Mich.) Said to have been found in an old patch of berries in Berrien County, Mich., by a Mr. Henry Gersandi and introduced by Mr. Lock in 1912. Its history is obscure. It is said to be grown quite extensively in Michigan for the Chicago market.

Plants below medium in vigor and number, severely injured by leaf-spot, unproductive; leaves variable in size, thick, light to medium green, rugose; flowers perfect, bloom in mid-season, variable in size, often from one to one and one-fourth inches across; petals roundish-oval, six to seven in number; stamens numerous, long; receptacle small, roundish; fruit-stems of medium length, slender, erect, single; calyx intermediate in size, flat to raised; seeds often sunken. Fruit matures very late; variable in size, very irregular, blunt-conic to wedge, sometimes necked, unattractive, somewhat dull, light red; apex variable in shape; flesh light red, whitish toward the center, very juicy, firm, sprightly; good in quality.

Inferior both in plant- and fruit-characters to other varieties of its season.

Jopp Favorite.— (W. S. Todd, Greenwood, Del.) A seedling of unknown parentage. originating with W. H. Jopp, Denton, Md., in 1911; introduced by Mr. Todd in 1916.

Plants numerous, vigorous, healthy, unproductive; leaves large, thick, dark green, rugose, glossy; flowers perfect, appear late, one and one-fourth inches across; petals large, roundish, six to eight in number; stamens numerous, long; receptacle of medium size, roundish-conic; fruit-stems long, intermediate in thickness, erect, branching; calyx of medium size, slightly raised; seeds raised. Fruit matures very late; unusually large, blunt-wedge, necked, dull, unattractive medium to dark red; apex blunt; flesh red thruout, juicy, firm, subacid; fair in quality.

Plant-habits desirable except in yield; a very late variety, with fruit of largest size which is well-retained thruout the season but which is too dull and unattractive in color and not of highest flavor.

Kellogg Prize.— (R. M. Kellogg Co., Three Rivers, Mich.) Said to be a chance seedling found in 1906 close to a brush heap near a field of berries and propagated by R. M. Sears, La Grange, Ill.; introduced in 1913 by the Kellogg Co.

Plants medium or below in number, intermediate in vigor, healthy, productive; leaves of medium size and color, thick, dull, rugose; flowers imperfect, appear in early mid-season, large, often more than one and one-half inches across; petals large, roundish-oval, six to eight in number; receptacle large, prominent; fruit-stems of medium length, thick, prostrate, branching; calyx large, raised, leafy; seeds often raised. Fruit matures late; above medium to large, blunt-conic to blunt-wedge, necked, medium to light red; apex slightly pointed; flesh light red thruout, juicy, firm, sprightly; fair to good in quality.

Plant-habits good; an imperfect-flowering variety, maturing late and shipping well; the later pickings were improvements in both size and color of fruit, the berries at that time making an unusually fine showing.

Knight No. 1.— (David Knight & Son, Sawyer, Mich.) A seedling of unknown parentage originating with Wm. H. Tracy, Gloucester, Ohio, about 1902; listed and described in the Knight catalog of 1916 as "No-Name-As-Yet;" not yet introduced.

Plants numerous, vigorous, healthy, very productive; leaves of medium size, thin, dark green, rugose; flowers imperfect, bloom in late mid-season, small, less than one inch across; petals small, usually five in number, roundish; receptacle small, roundish-conic; fruit-stems long, of medium thickness, semi-erect, branching; calyx intermediate in size, much raised, leafy, attractive green; seeds raised. Fruit matures late; above medium to large, conic to wedge, strongly necked, dull, very light red; apex pointed; flesh light red to the center, juicy, lacks in firmness, hollow at the core, mild, sweet; good in quality.

Fruit too light colored and too soft; surpassed by other varieties of its season.

La Bon.— (H. J. Schild, Ionia, Mich.) A seedling of unknown parentage grown by Mr. Schild in 1909; introduced in 1916 by leading small-fruit nurserymen of various states.

Plants numerous, vigorous, healthy, productive; leaves medium in size, thick, very dark green, smooth, glossy; flowers perfect, bloom in early mid-season, about one inch across; petals small, roundish, five to eight in number; stamens numerous, short; receptacle large, conical; fruit-stems of medium length and thickness, semi-erect, branching; calyx intermediate in size, flat; seeds raised, prominent. Fruit matures medium early; large, irregularly furrowed, oblate to roundish-oblate, glossy, light red, colors unevenly; apex obtuse, indented; flesh light red, becoming whitish toward the center, not juicy, medium in firmness, with hollow core, mild, not high-flavored; fair in quality.

Plant-habits unusually good; the long, dense root-system accounts for the designation "alfalfa-rooted" given by Mr. Sibert. Fruit is characteristic in the flattened shape, furrowed surface, hollow core, apex often broken apart, and the strongly raised seeds. Berries inclined to green tips, of desirable size but unattractive both in shape and color, and lacking in firmness.

Lady Corneille.— (W. F. Allen, Salisbury, Md.) Said to contain a mixture of the blood of Klondike, Bubach, Red Bird and Mary, originating in 1909 with Mrs. T. C. Corneille, Ponchatoula, La.; introduced in 1912 by Lee Lanier of that place.

Plants numerous, vigorous, usually healthy, unproductive; leaves small, thin, medium to dark green, smooth, glossy; flowers perfect, bloom early, one and one-fourth inches across; petals large, roundish-oval; stamens numerous, long; receptacle of medium size; fruit-stems short, thick, semi-erect, branching; calyx large, raised, leafy; seeds slightly raised. Fruit matures medium early; above medium in size, furrowed, wedge to blunt-conic, necked, often dark red; apex slightly pointed; flesh light red, becoming whitish toward the center, juicy, firm, sprightly, almost tart; fair in quality.

Plants unproductive; fruit strongly furrowed, inclined to green tips; the leafy calyx detracts from appearance; a good shipper but not of high flavor or quality.

McAlpine.— (W. F. Allen, Salisbury, Md.) A cross between Glen Mary and Bubach made by Hausmann Bros., Hilton, N. J., in 1909; developed by Louis Becker & Son of that place and in 1915 introduced by Mr. Allen.

Plants numerous, vigorous, injured by leaf-spot, productive; leaves small, thin, rather light green, smooth; flowers perfect, appear in early mid-season, one and one-eighth inches across; petals of medium size, roundish, five to eight in number; stamens numerous, long; receptacle small, roundish; fruit-stems long, slender, erect, single; calyx of medium size, slightly raised; seeds somewhat sunken. Fruit matures late; of large size, furrowed, blunt-wedge to blunt-conic, necked, dull, light red; apex indented, green-tipped; flesh light red, becoming whitish toward the center, very juicy, not firm, mild subacid; fair in quality.

Plant-habits good except in resistance to disease; a late-maturing variety with fruit of good size but inclined to green tips, rather soft for a good shipper, too light red for a very attractive berry, very light at the center, inferior in flavor and quality.

Magic Gem.— (R. M. Kellogg Co., Three Rivers, Mich.) A seedling of unknown parentage developed by Edw. Vance, Twin Falls, Idaho, in 1912; introduced by the Kellogg Co. in 1916.

Plants medium in number and vigor, healthy, productive; leaves rugose; flowers perfect, bloom in late mid-season; stamens medium in number, short; receptacle broad-conic; fruit-stems of medium length, thick, semi-erect, branching; calyx large, slightly raised, leafy, attractive green; seeds variable in position. Fruit matures in late mid-season; very large, dropping somewhat at the close of the season, broad-conic, with a few cockscombs, slightly necked, attractive medium red; apex somewhat pointed; flesh medium red to the center, juicy, very firm, the larger berries with a hollow core, pleasantly sprightly, high-flavored; very good in quality.

Plant-habits unusually good; a perfect-flowering variety blooming and ripening in late mid-season; altho the surface of the largest berries is furrowed and irregular, the general appearance is very attractive and the flesh-characters much above the average especially in quality; worthy of trial either for home use or commercial purposes.

Marshall Improved.— (E. W. Townsend, Salisbury, Md.) The history of this variety is obscure. It is stated in Mr. Townsend's catalog that he purchased this strain of Marshall from an agent canvassing in his territory. Nothing appears to be known regarding its origin.

Plants healthy, medium in number, vigor and productiveness; leaves of average size and thickness, light green, rugose; flowers perfect, large, often one and one-fourth inches across, bloom early; petals crinkly, broad-oval, five to eight in number; stamens numerous, long; receptacle large, roundish; fruit-stems short, thick, erect, branching; calyx large, flat or depressed, discolored; seeds variable in position. Fruit matures early; large to medium, irregularly furrowed, roundish-conic, light red, dull; apex obtuse; flesh light red, becoming whitish toward the center, medium in juiciness and firmness, mild subacid, not high-flavored; fair in quality.

As fruited at this Station the variety is no improvement on the Marshall, ranking decidedly inferior to that well-known variety nor does the fruit show much resemblance either in color or flavor.

Minnesota No. 3.— (Experiment Station, St. Anthony Park, Minn.) Originated by Chas. Haralson in 1909 at the Minnesota Fruit Breeding Farm, Excelsior, Minn. It is a cross between Dunlap and Pokamoke; introduced by the Experiment Station about 1914.

Plants numerous, vigorous, nearly free from leaf-spot, very productive; leaves of medium size, thickness and color, glossy, rugose; flowers perfect, bloom in early mid-season, one inch across; petals of medium size, roundish-ovate, five to seven in number; stamens numerous, medium in length; receptacle conical, rather small; fruit-stems intermediate in length and thickness, nearly prostrate, branching into long, slender pedicels; calyx large, much raised, attractive green, with long, reflexed sepals; seeds slightly sunken. Fruit matures medium early; large to medium, dropping in size as the season advances, conic, the base irregular, strongly necked, attractive, glossy, medium to dark red; apex distinctly pointed, often green-tipped; flesh red thruout, very juicy, firm, pleasantly sprightly; good in quality.

Resembles Dunlap in type, of good color and pleasing flavor; greatest defect appears to be lack of desirable size.

Minnesota No. 1017.— (Experiment Station, St. Anthony Park, Minn.) Originated at the Minnesota Fruit Breeding Farm, Excelsior, Minn., in 1909 by Chas. Haralson. A cross between Dunlap and Progressive. It is said to be one of the most promising everbearing strawberries produced at the Fruit Breeding Farm; introduced by the Experiment Station about 1914; an "everbearer."

Plants few in number, medium in vigor, nearly free from leaf-spot, very productive considering the number of plants; leaves small, thick, dark green, smooth, glossy; flowers perfect, open in early mid-season, one and one-eighth inches across; petals of medium size, roundish; stamens medium in number and length; receptacle roundish; fruit-stems above medium in length, thick, erect, branching; calyx flat, dingy green;

seeds raised. Fruit matures in mid-season; above medium, dropping to small, irregular-conic to blunt-wedge, broad and flat at the base, not very attractive, somewhat dull, medium red; apex obtuse; flesh red thruout, juicy, very firm, with hollow core, sprightly, almost tart; good in quality.

Altho very productive, the greatest defect appears in lack of size, as grown on the heavy clay of this Station.

Minnetonka.— (E. W. Potter, Leslie, Mich.) A seedling of Splendid crossed with Beder Wood in 1904; introduced in 1909.

Plants of medium number, vigor and productiveness, healthy; leaves small, thick, dark green, rugose, glossy; flowers perfect, bloom in early mid-season, one inch across; petals of medium size, roundish, six to seven in number; stamens intermediate both in number and in length; receptacle roundish-conic; fruit-stems very short, thick, prostrate, branching; calyx medium in size, flat; seeds raised. Fruit matures in early mid-season; inferior in size, blunt-wedge to blunt-conic, dull, unattractive medium red; apex somewhat pointed; flesh light red, juicy, very firm, sprightly; fair in quality.

This variety appears to have but little value as fruited on the Station grounds; easily surpassed by other varieties of its season.

Morgan No. 21.— (J. A. Morgan, Scottsville, N. Y.) A chance seedling found by Mr. Morgan in 1911 growing in a fence corner on his farm; not yet introduced.

Plants of but medium number, unusually vigorous and tall, healthy, very productive; leaves of largest size, thick, dark green, rugose; flowers imperfect, bloom in late mid-season, about one inch across, cup-shape and with a large, leafy, calyx; petals roundish, six to eight in number; receptacle medium in size, roundish-conic; fruit-stems very long, thick, erect, branching; calyx very large, depressed or flat, leafy, attractive green; seeds usually raised but variable. Fruit matures medium early to early mid-season; of largest size, dropping rapidly in size as the season advances, the largest berries irregularly furrowed, roundish-conic to blunt-wedge, some berries inclined to almost oblate, dark red, attractive, glossy, colors evenly; apex very obtuse, indented; flesh variable in color, very firm, juicy, somewhat sprightly; very good in quality.

A seedling with merits considerably above the average; plants unusually tall, vigorous and with very large leaves; must be planted with other varieties as the blossoms are imperfect; flowers peculiarly cup-like, with a large, leafy calyx; fruit-stems of longest size yet erect; calyx attractive in color; fruit almost fig-like in texture, one of the best of shippers, often truncate in shape; altho the later berries are not above medium size, they are uniform in general appearance, the smallest ones slightly seedy; quality much above the average run of seedlings; worthy of extended trial.

Myrtle Murrell.— (J. T. Lovett, Little Silver, N. J.) A seedling of Hoffman crossed with Heflin in 1905 by S. S. Murrell, Marion Station, Md.; introduced by Mr. Murrell in 1913.

Plants very numerous, medium in vigor, unproductive, injured by leaf-spot; leaves very small, thin, light green; flowers perfect, bloom early, over one inch across; petals roundish, six to eight in number; stamens very long, numerous; receptacle of medium size, roundish; fruit-stems short, slender, erect, single; calyx of medium size, raised, discolored; seeds raised. Fruit matures in mid-season; inferior in size, long-conic, slightly necked, unattractive, dull, light red; apex pointed; flesh light red, becoming whitish toward the center, juicy, variable in firmness, mild, sweet; good in quality.

Disappointing both in plant and fruit; a rather long, conical, light red berry inferior both in size and color.

Nellis Triumph.— (J. H. Nellis, Paterson, N. J.) A seedling of unknown parentage discovered by Mr. Nellis in 1912; introduced in 1917 by The W. F. Allen Co., Salisbury, Md. and by W. B. Kille, Swedesboro, N. J. It is thought by some to resemble Clyde.

Plants intermediate in number and vigor, healthy, very productive; leaves of medium size, color and thickness; flowers semi-perfect to perfect, open early, one and one-eighth inches across; petals roundish, six to eight in number; stamens numerous;

receptacle roundish-conic, of medium size; fruit-stems variable in length, thick, prostrate, branching freely into long, slender pedicels; calyx flat to slightly depressed; seeds variable in position. Fruit matures in early mid-season; large, retains size well thruout the season, blunt-conic, broad at the base, light red, dull; apex obtuse; flesh light red, very juicy, lacks in firmness, mild subacid; good in quality.

One of the most productive varieties, holding up well both in yield and size of fruit thruout the season; unfortunately the berries are too light and dull in color and bruise easily; of doubtful value in spite of its desirable flavor and quality.

Onward.— (Samuel Cooper, Delevan, N. Y.) A cross between Autumn and Cooper made in 1907 by Mr. Cooper and introduced by him in 1914; an " everbearer."

As grown on the soil at this Station, Onward cannot be distinguished from Advance and the reader is referred to that variety for description.

Oregon.— (Oregon Nursery Co., Orenco, Oregon.) This variety is said to be a cross between Marshall and Jessie made about 1898 by A. F. Hofstadtler, Salem, Oregon, first introduced in 1902 as Admiral Dewey, later was changed to Oregon and was recently re-introduced as New Oregon.

Plants numerous, of medium vigor, healthy, very productive; leaves small, intermediate in thickness and color; flowers perfect, appear early, one and three-eighths inches across; petals roundish, seven to nine in number; stamens numerous, short; receptacle large, very blunt, broad at the base; fruit-stems long, slender, erect, single; calyx of medium size, variable in position; seeds slightly raised. Fruit matures early; of large size which is well-retained thruout the season, very irregular in shape, averaging roundish-conic, attractive, glossy, medium to dark red, colors unevenly; apex blunt; flesh red thruout, juicy, firm, pleasantly sprightly; good in quality.

A very productive variety, maturing early; altho somewhat variable both in color and shape, appears worthy of test on account of high quality and pleasing flavor.

Pearl.— (L. J. Farmer, Pulaski, N. Y.) Said to have been originated by J. W. Loomis, Hobart, Indiana; a seedling of Gandy; introduced in 1912 by the originator. Statements are at variance in regard to the history of this variety.

Plants numerous, large, healthy, productive; leaves large, thick, medium green, rugose; flowers perfect, bloom very late, one and one-fourth inches across; petals roundish-oval, six to eight in number; stamens numerous, long; receptacle large, prominent; fruit-stems of medium length, very thick, erect, single; calyx large, flat or slightly raised; seeds raised. Fruit matures very late; very large, retaining size well as the season advances, irregularly furrowed, blunt-conic to wedge, sometimes slightly necked, medium to light red; apex obtuse, indented, not always well-developed; flesh well-colored to the center, juicy, very firm, sprightly; good in quality.

Plant-habits good; the late-blooming flowers are not subject to frost-injury; fruit matures among the very latest varieties, one of the best of shippers, as well as choice in size of berry, attractive in appearance except for a number of berries undeveloped at the apex; worthy of test for a sprightly, late variety of high quality.

Premier.— (R. M. Kellogg Co., Three Rivers, Mich.) A seedling of unknown parentage sent by E. H. Riehl, Alton, Ill., in 1912 to the Kellogg Company; introduced by that company in 1915.

Plants medium in number and vigor, healthy, productive; leaves small, of medium thickness and color, slightly rugose, dull; flowers perfect, season of bloom early, one and one-eighth inches across; petals roundish-oval, six to eight in number; stamens numerous, long; receptacle of medium size, conic; fruit-stems very short, thick, prostrate, branching; calyx large, raised to flat, attractive green; seeds sunken. Fruit matures medium early; above medium to small, long-conic to long-wedge, with furrow running from base to apex on the largest berries, necked, attractive, glossy, medium red; apex pointed; flesh red to the center, juicy, firm, often with a firm core, somewhat sprightly; good in quality.

A fairly good berry in flesh-characters but the shape is against it and the size is too small.

Rewastico.— (W. F. Allen, Salisbury, Md.) Said to be a seedling of unknown parentage originating with Thomas B. Howard of Wicomico County, Md., about 1908; introduced by Mr. Allen in 1913.

Plants produced in great numbers, vigorous, healthy, very productive; leaves of medium size and thickness, very dark green, nearly smooth; flowers perfect, intermediate in season of bloom, one and one-fourth inches across; petals large, roundish, five to seven in number; stamens numerous, long; receptacle of medium size, roundish; fruit-stems long, very thick, erect, single; calyx large to medium, leafy, usually slightly raised, with very broad sepals; seeds sunken. Fruit matures late; large, blunt-wedge to roundish-conic, slightly necked, attractive medium red, somewhat glossy; apex obtuse; flesh usually red thruout, very juicy, firm, tart, not pleasant-flavored; inferior in quality.

Characteristic in the large number of runners produced, making a wide row, and in the pleasing appearance at blooming time, the large, showy blossoms being scattered thickly among the dark green leaves; general appearance attractive in size, color and shape, but too sour for most palates.

Richmond.— (J. T. Lovett, Little Silver, N. J.) A seedling of Lady Thompson originating in 1901 with Mark T. Thompson, Richmond, Va.; introduced in 1903 by Mr. Thompson.

Plants few in number, of medium vigor, healthy, very productive; leaves thick, medium in size and color, rugose; flowers semi-perfect to perfect, bloom early, nearly one and one-fourth inches across; petals roundish, seven to eight in number; stamens numerous, long; receptacle of medium size, conic; fruit-stems intermediate in length and thickness, semi-erect, branching; calyx large, raised, with long, narrow sepals; seeds sunken. Fruit matures in mid-season; above medium to small, oblong-conic, necked, light red, not very glossy; apex pointed; flesh red thruout, juicy, firm, variable in flavor; fair in quality.

Blossoms showy; a light red berry characteristic in its long-conic shape; a good shipper but disappointing in size, shape and flavor.

Standpat.— (C. N. Flansburgh & Son, Jackson, Mich.) A seedling of Dunlap crossed with Pan American by Harlow Rockhill, Conrad, Iowa, in 1906 and introduced in 1914 by Flansburgh & Son. An "everbearer."

Plants very few, inferior in vigor, health and yield; leaves small, of medium thickness and color; flowers perfect, open early, very small, three-fourths inch across; petals of smallest size, five to seven in number; stamens variable in number and length; receptacle large for the size of the blossom, prominent; fruit-stems very short, slender, prostrate, single; calyx small, depressed, discolored; seeds prominent, raised. Fruit matures very early; medium to small, blunt-conic, dull, unattractive, dark red; apex variable in shape; flesh variable in color, juicy, medium in firmness, subacid; inferior in flavor; poor in quality.

For some reason both plants and fruit were practically a failure. Possibly might give different results another year or on another type of soil.

Todd.— (W. S. Todd, Greenwood, Del.) A chance seedling found by Mr. Todd in 1909 on his farm near a bed of Sample and Wm. Belt; introduced by Mr. Todd in 1914 as Todd's Late Champion.

Plants few in number, vigorous, injured by leaf-spot, productive; leaves very large, thick, dark green, rugose; flowers imperfect, variable in size, bloom late; petals broad-oval, five to seven in number; fruit-stems short, very thick, erect, branching; receptacle large, roundish-conic; calyx medium in size, flat to slightly raised; seeds sunken. Fruit matures very late; large to medium, wedge to blunt-conic, the larger berries furrowed and occasionally cockscomb in shape, unattractive light red, colors unevenly; apex obtuse; flesh light red, becoming whitish toward the center, medium juicy, lacking in firmness, somewhat sprightly; fair in quality.

Undesirable both in color of surface and flesh; too soft for a good shipper; surpassed by other varieties of its season.

Warren.— (W. F. Allen, Salisbury, Md.) Said to be a chance seedling found by S. H. Warren, Auburndale, Mass., many years ago; introduced by Mr. Allen in 1914.

Plants numerous, of medium vigor, productive, injured by leaf-spot; leaves small, thick, very dark green, rugose; flowers perfect, bloom in mid-season, very large, often more than one and one-half inches across; petals large, broad-oval, six to seven in number; stamens numerous, long; receptacle of medium size, blunt-conic; fruit-stems short, thick, semi-erect to prostrate; calyx intermediate in size, depressed or flattened, leafy, attractive green; seeds raised. Fruit matures very late; large, unusually good in size thruout the season, blunt-conic, glossy, attractive medium red; apex obtuse; flesh red thruout, juicy, firm, sprightly; good in quality.

Requires further testing to determine its value as it possesses some most excellent qualities as well as some undesirable; plant-habits good except in susceptibility to leaf-spot; a very late-ripening variety with fruit of largest size, a good shipper, somewhat variable in color; some berries seedy in appearance; quality above the average.

Wide-awake.— (Louis Hubach, Judsonia, Ark.) A seedling of Aroma originating in 1910 with Mr. Hubach; introduced by him in 1913.

Plants intermediate in number and vigor, nearly free from leaf-spot, productive; leaves of medium size, thickness and color; flowers perfect, open very early, nearly one and one-fourth inches across; petals roundish, seven to eight in number; stamens numerous, long; receptacle large, conic; fruit-stems variable in length, slender, semi-erect, branching; calyx small, depressed or flat, often discolored; seeds raised. Fruit matures in mid-season; large, the surface of the largest berries furrowed, wedge to blunt-conic, unusually glossy, attractive, very dark red; apex obtuse, often green-tipped; flesh dark red to the center, juicy, very firm and meaty, somewhat tart, not high in flavor; inferior in quality.

Plants unusually attractive at blooming time, as the blossoms are conspicuous; one of the most desirable kinds in size and color of fruit, fig-type in its texture, unsurpassed as a shipper; unfortunately the greatest defects are in flavor and quality; possibly on other soil-types or in other seasons this condition would improve and if so, the variety would possess high merit.

Wildwood.— (W. F. Allen, Salisbury, Md.) Found in a bed of "Queen," in 1904 by E. R. Foss, Salem, Iowa; introduced by W. F. Allen, Salisbury, Md., in 1911.

Plants very numerous and vigorous, foliage subject to mildew, very productive; leaves rather small, thin, dark green, slightly rugose; flowers perfect, bloom in early mid-season, variable in size, averaging one inch across; petals of medium size, oval, five to six in number; stamens numerous, long; receptacle small, roundish; fruit-stems long, slender, erect, single; calyx of medium size, raised; seeds slightly raised. Fruit matures very late; medium to small, blunt-conic, strongly necked, very dull, unattractive medium red; apex obtuse; flesh light red thruout, medium juicy, lacking in firmness, mild, aromatic; of fair quality.

Altho the plants are productive and are extremely vigorous, they mildew badly; fruit is decidedly unattractive, dull in color, of small size, a poor shipper; base of berries strongly necked; general appearance resembles a wild strawberry.

The above description is from stock from the introducer, yet the plants may not be true to name for the true Wildwood is said to be early in season and the berries roundish, varying greatly from the fruit just described.

Wittlinger No. 1.— (G. J. Wittlinger, Jr., Clarence Center, N. Y.) A seedling of unknown parentage grown by Mr. Wittlinger, Jr., in 1913; sent to this Station for testing in 1916.

Plants numerous, vigorous, healthy, unproductive; leaves large, of medium thickness, dark green, slightly rugose; flowers perfect, bloom in early mid-season, one and one-eighth inches across; petals small, roundish, six to eight in number; stamens below medium in number; receptacle of medium size, roundish; fruit-stems intermediate in length and thickness, prostrate, branching; calyx medium in size, flat, unattractive green; seeds slightly raised. Fruit matures in early mid-season; above medium in size, blunt-conic, dull, unattractive light red; apex blunt; flesh light red, becoming whitish toward the center, juicy, medium firm, mild, sweet; good in quality.

Altho of fairly good size, the fruit is too light red in color at both surface and center.

Woodrow.— (Wilkins & Co., Salisbury, Md.) The history of the Woodrow appears to be obscure except that it was introduced by Wilkins & Co., the spring of 1915, as "Early Woodrow."

Plants intermediate in number and size, healthy, productive; leaves of medium size and thickness, dark green, rugose, glossy; flowers perfect, open in late mid-season, one and one-eighth inches across; petals roundish-ovate, six to eight in number; stamens intermediate in number, short; receptacle roundish-conic to wedge; fruit-stems long, prostrate, branching; calyx raised, dull green, tinged with red; seeds variable in position. Fruit matures in mid-season; variable in size, long- and flat-wedge to long-conic, furrowed, necked, medium to dark red, often dull; apex somewhat pointed; flesh red to the center, juicy, very firm, often with a firm core, mild, not high-flavored; fair in quality.

Altho the plant-habits are good, the fruit is inferior in uniformity of size, shape and in flesh-characters.

A NON-PARASITIC MALADY OF THE VINE.*

F. E. GLADWIN.

SUMMARY.

1. The trouble under discussion was first observed in a young vineyard during the summer of 1910. Other vineyards growing on the Experiment Grounds have since shown the affection from year to year in varying amounts.

2. The malady at its first appearance was supposed to be chlorosis of the Old World species, but later observations disclosed their dissimilarity.

3. Neither the leaf-blight disease of the vine nor the California vine disease is due to the same causes as the trouble under study.

4. The affection manifests itself on light soils during drouth, or on heavy, impervious soils when excessively wet.

5. Vines affected with the trouble first show a streaked pallidness of the leaves in the intervascular spaces. Later these streaked areas become yellow. The discoloration is more marked near the margins and eventually the pallid areas coalesce and form a yellowed band extending around the margin. As the season advances this band dies and becomes functionless. Isolated areas of the leaf blade deaden and when these join, a considerable part of the leaf tissue may become functionless. When the entire leaf is affected the outer margin often curls upward.

6. The injury is cumulative unless favorable conditions are established in the succeeding years, i. e., optimum rainfall, etc.

7. As a result of the injury to the foliage, growth is materially checked and the wood usually fails to mature well. The fruit does not color nor is the normal amount of sugar fixed. "Shelling" may result.

8. Soils deficient in organic matter and hence in their water-holding capacity are associated with the trouble. Heavy, wet soils likewise contribute to the affection. The sickness is very common to the Volusia Silt Loam type of soil.

* Reprint of Bulletin No. 449, March, 1918.

9. Young vines with their limited root-range are oftener affected than the older, well established ones, tho the latter may be affected under certain conditions, such as a greatly diminished water supply.

10. Applications of sulphate of iron — the general measure of control for chlorosis in Europe — failed to lessen the affection. Nitrogen, phosphorus, potassium, sodium or calcium did not affect the degree of injury when applied to the soil about sick vines.

11. The incorporation of considerable amounts of organic matter with the soil is a possible corrective. Stable manure and green manures will tend toward this end. Tile drainage is a necessary requisite in many vineyards growing on the heavy soil types, since the interposition of a hardpan, which is fairly common in the Chautauqua and Lake Erie Fruit Belt, limits the vertical root range.

12. Early spring plowing and frequent summer tillage, that result in the maintenance of a dust mulch, conserve moisture during seasons of drouth.

13. Affected vines should be closer pruned than normal ones. The removal of a badly injured vine and its replacement by another plant is rarely successful. When an injured vine of necessity must be removed it can best be replaced by layering a cane from the adjacent vine at one side of the vacated space.

INTRODUCTION.

During the summer of 1910 the attention of the writer was attracted to the sickly appearance of the leaves of several Concord vines growing in a young vineyard three years set, on the grape experiment grounds of this Station at Fredonia, N. Y. In 1911 the trouble again appeared in this vineyard and in others six and seven years planted. In 1912 the affection was noted in all the vineyards previously mentioned, and, in addition, in one twenty years planted and located on a very different soil type from the others. In 1913 the trouble was still apparent in all the vineyards previously noted and in two others planted in 1910. In 1914 the sickly appearance was observed within the limits of the previous years but the twenty-three-year vineyard was practically normal. Since this time the malady has been gradually lessening, isolated areas only remaining in two vineyards that were much affected in 1917. Of the seven years that the trouble has been under observation it was in the most aggravated form in 1912.

IDENTITY OF THE TROUBLE.

At its first appearance the malady was supposed to be chlorosis, a disease common to the Old World species of the vine; but closer observation and a review of the literature pertaining to this disease tend to prove that chlorosis and this trouble affecting the Concord are not due to the same causes. Most writers on the Old World disease state that it is caused or favored by lime in the soil. This can not be true of the trouble under discussion for lime is very deficient in the soils of the Chautauqua and Erie Grape Belt, and especially is this true in the vineyards where these data were taken.

The leaf-blight disease of the vine described by Fairchild,[1] while having some symptoms and environmental factors in common, differs from the one under observation in several material points. He states that leaf-blight is common only to young vines three to four years set. Our observations show that under certain conditions, which will be detailed later, the trouble may be common on much older vines. Again he says, " the worst attacks of this disease occur upon cold, heavy soils containing a large percentage of clay and rich in nitrogenous matter." While it is true that four of the vineyards under discussion are situated upon the heavy soil types, it should also be stated that they are deficient in nitrogen, as has been determined by chemical analysis and from their response to applications of stable manure and commercial nitrogen. The twenty-three-year vineyard, in which the disease was observed in severe form in only one year, is planted on a loose, gravelly loam approximately 20 feet deep. Another is on a light clay to silt loam that is well drained.

In some respects the symptoms manifested by the sick vines are similar to those of the California vine disease of Vinifera varieties, discussed by Pierce,[2] yet the two are so different in other particulars that the troubles can not be produced by the same causes, however alike they may be in some characters. Pierce states that cuttings taken from vines affected with the California vine disease carry with them the disease and thus it is perpetuated. Cuttings taken from vines with the affection under discussion have, after three years' growth, developed as perfectly normal vines without any symptoms of the disease.

[1] Fairchild, D. D. Diseases of the grape in western New York. *Jour. Myc.* 6: 95–98. 1891.

[2] Pierce, N. B. Grape diseases on the Pacific Coast. U. S. Dept. Agr., Farmers' Bul. 30:7–14. 1895.

In the following particulars the malady resembles the " Drouth Spot " disease of apples studied by Mix[3]: Both are favored by a lack of soil moisture. In each abnormal condition of roots is not necessary to bring about the disease. While the leaf characters are quite similar yet they differ in some respects, as for example the disease under discussion seems to affect larger and more well-defined areas than in drouth spots.

However, no die-back of the shoots was observed during the current year but as will be shown later the newly formed canes were injured. Thus far, but one case has been observed upon the so-called better soils, the injury being largely confined to the thin, shallow soils. The grape berries were not affected in appearance except as to size and color at maturity, while in drouth spot the fruit shows diseased areas. Excessive soil moisture is not apparently a contributing factor to the "drouth spot disease", while with the affection under study there is apparently a relationship.

CHARACTERS OF THE DISEASE.

During the dormant season there are no external characters that would indicate that the trouble is present, except perhaps that wood growth is not as well matured, nor the amount grown so great as with the unaffected vines. However, if these conditions are used as criteria in detecting diseased vines, it can be done with certainty only with vines located in similar situations as to soil, elevation and age.

Early in July in average seasons the apical leaves of affected shoots show a streaked yellowing in the intervascular spaces. However, the vineyardist rarely observes this, the beginning stage of the affection. A little later, other leaves on the shoots develop pallidness. The discoloration is more marked near the margin and eventually the pallid areas coalesce and form a yellowed band extending around the margin. As the season advances this band of tissue dries and becomes functionless. The deadened area is further increased by a drying out of the intervascular tissue, extending from the margin inward to the midrib, until in extreme cases the entire tissue of the leaf, except that along the main veins, becomes brown and dead. Often only one side of the leaf shows this extreme stage; in other instances after the marginal tissue has deadened, isolated

[3] A. J. Mix. Cork, drouth spot and related diseases of the apple. N. Y. Agr. Ex. Sta. Bul. 426, 473–522. 1916.

and scattered spots of dead tissue develop without order over the blade. These spots often coalesce so that dead areas of considerable size are produced quite apart from those at the margin. A leaf that has gone thru these successive stages of dying back has only narrow strips of functioning tissue immediately adjacent to the principal veins and veinlets. When the entire leaf area is affected the margin often curls upward.

During the first year an affected vine may be diseased in but few shoots from a single cane, or at most in two or three canes. The year following additional canes usually show the trouble and eventually the whole vine is affected. The disease appears to be cumulative. Vines have been observed that were completely defoliated some time previous to the period of fruit maturity. The fruit of affected vines does not color well, nor is the normal amount of sugar fixed. The berries do not acquire full size, and in extreme cases "shell" from the cluster. When the vine is only moderately affected, "shelling" may not follow, but the fruit is not attractive nor palatable.

Growth is checked materially and the new wood does not mature properly; as a consequence it is unfitted for next year's fruiting, much of it winter-kills, and that not so killed is soft, light in weight and apparently is deficient in stored plant food. The difficulty of obtaining desirable canes for fruiting becomes a serious problem.

OCCURRENCE AND RELATIONSHIP OF AFFECTION TO SOIL.

In 1912, when the trouble was first observed in the twenty-three-year vineyard, much valuable information was obtained, confirming the belief that the sickness is associated with the water content of the soil and the ability of the root systems to absorb it. This vineyard is growing on a very open, gravelly-loam soil approximately 20 feet in depth. In times of severe drouth the vines in it, particularly over the higher parts, are checked in their growth, but if the tillage has resulted in a good dust mulch this has been largely obviated. Since 1909, four plats, of two rows each, have been seeded during late July each year to a green-manure crop of mammoth clover. This crop is plowed under early each spring. In 1912 it was decided to allow the clover in two of the plats, one limed, the other not, to grow during the summer, mow at intervals and leave

the straw as a mulch. The summer of 1912 was very deficient in rainfall. For twenty-seven days previous to July 13, no rain fell. On this date a rainfall of .41 inch occurred. Some days previous to this rainfall the vines in the clover-mulched plats began to show symptoms of sickness which finally developed into the most severe case yet observed. The characters were in every way typical of those vines already cited. In the depression of the rows the injury was not nearly so bad as on the higher locations. The rows immediately bounding the affected plats showed negligible amounts of the trouble, while there was practically none in the other parts of the vineyard. No differences in degree of injury were noted between the limed and unlimed plats, while the vines in the other two clover plats, plowed in the spring and cultivated at frequent intervals, were perfectly normal. In 1913 the vines affected in 1912 showed somewhat the effect of the previous injury, but in 1914 they were normal, healthy vines again. In 1913 and following seasons the clover plats have been annually plowed and given good summer tillage.

Observations made on July 13, 1915, showed the trouble in its first stages within practically the same boundaries in all but the vineyard just alluded to, but apparently fewer vines were affected and these in less degree.

In a vineyard located on a black silt, a complete system of tile drainage had been installed in the fall of 1909. At the time this work was done one or more underground springs were located beneath the black silt areas. As a large number of sick vines had been noted over this soil type several borings were made with the soil auger about the bases of the worst of them. The water table on this date, July 13, was found to be about 2½ feet below the surface. This evidently was much higher than in average years, owing to a total rainfall of 10.27 inches for June and July. Of this total, 8.42 inches fell previous to the date of sampling. The surface soil here consists of five or six inches of black loam, underlaid by a layer of very stiff blue and yellow clay from two to two and a half feet in thickness. Below this clay there is a stratum of coarse sand containing a few small pebbles. The free water was found in this sand layer. A run of tile was opened alongside and within two feet of a vine affected with the trouble. The tile was perfectly clear and carrying a little water. The roots of this vine had not penetrated

Plate XXXIV.— Grape Leaves Showing Initial and Later Stages of Affection.

Upper: Pallid areas in intervascular spaces.
Lower: Marginal killing with development of isolated dead areas.

Plate XXXV.— Grape Leaves Showing Advanced Stages of Affection.
Upper: Marginal killing more advanced than in Plate XXIV.
Lower: Greater part of leaf-tissue functionless; light areas along principal veins still active tissues; leaf ruptured at left of midrib.

Plate XXXVI.— Injured Foliage on Concord Vine in Silt Soil.

Leaves from top shoots dried and much of tissue fallen leaving only petiole and primary veins. Practically all foliage of this vine lost before close of growing period and fruit not harvested.

to more than eight inches, while the greater part of the feeding, fibrous roots were only down from four to six inches. It would appear that here the impervious nature of the sub-soil contributes largely to the sick condition of the vines, thru limiting the wide distribution downward of the active feeding system into the zone of abundant water supply. The clay hardpan interrupts the downward percolation of the rainfall, to the end that there is a rapid runoff of that in excess of the amount that can be taken in as a reserve by the friable but shallow surface soil. The saturation of this limited depth in time of excessive rainfall seriously interferes with the proper aeration of the root system. Likewise the interposed clay hardpan interrupts capillarity from the porous, water-bearing sand, upward to the root zone. In 1916 and 1917 the sickness was again present over this area, but apparently in somewhat diminished form.

Since 1915 the trouble has practically disappeared from the young vineyard mentioned as on a knoll made up of yellow silt. It was believed during the first years of this study that the only remedy here was the removal of the greater number of the sick vines and their replacement by others from the nursery; however, no vine has been removed from the vineyard by reason of the affection. It is probable that the vines here will in time acquire a root system extensive enough to supply the moisture losses thru evaporation and transpiration. The water storage capacity of this soil has been greatly increased by the turning under each season of green manures. Our observations indicate that newly planted vines in soils deficient in organic matter usually show the sickness under discussion for the first few years after planting, but tend to overcome the trouble as they become older and in closer contact with the soil. In 1917 there was no indication that these vines had been other than normal at any stage of their development.

FACTORS THAT CONTRIBUTE TO THE AFFECTION.

Considering the facts at hand it would seem that a lack of available soil moisture, at critical periods in the vine's growth, or a lack of root aeration as a result of the impervious sub-soil together with the shallow depth of surface soil, are the principal contributing factors to the affection. With this soil type the sickness is at its height in seasons of drouth as well as in those of excessive rainfall.

Soils such as the yellow silt are generally deficient in organic matter, and hence in their water-holding capacity. With them the affection is worst in seasons of drouth and least in those of normal rainfall. During early summer the vine makes a rapid growth of succulent shoots and leaves which require large amounts of water to develop. The loss thru transpiration as well as from soil evaporation is greatly favored in the Chautauqua-Lake Erie Fruit Belt by the dry prevailing winds from the south and southwest. In the case of the vines growing under the clover-mulch system in 1912, the injury was probably influenced by the added moisture requirements of the growing clover roots, together with a mulch insufficient to check soil evaporation as thoroly as the usual dust mulch. It should be stated here that the result with a mulch in this instance is not indicative of the value of the practice, as the amount of straw obtained from the two cuttings did not suffice even to furnish a thin covering over the soil area. Had the season been one of normal to above normal rainfall it is believed that no such ill effects would have occurred with these vines. The fact that the injury was considerably less in a depression where soil moisture was more abundant tends to this belief.

Reports from vineyardists and many observations in vineyards away from the Station lead to the conclusion that the trouble is wider spread than our earlier observations indicate. As new plantings, under soil conditions here outlined, come to bearing, the affection is liable to be more prevalent, since the soils more fitted for vineyard planting are largely so utilized, leaving available only the light, thin soils or the poorly drained clays. Invariably the trouble from the various localities is reported under the same situations and conditions as outlined herein. The reports also agree in that it is usually the newly planted vineyard that is affected.

CONTROL MEASURES.

That the trouble is connected in some way with the root system in its relation to the soil was evident early in the observations. The first affected vines extended diagonally across a knoll composed in large part of a light yellow silt, and in each row the knoll practically limited the extent of diseased vines.

As the appearance of the injured foliage indicated a possible relationship with chlorosis of Vinifera varieties growing in France,

the accepted remedial measures for its control in that country were tried out in the Station vineyard with a number of badly affected vines located on the above soil type. Other nearby vines were reserved as checks. Sulphate of iron was applied to the soil about the bases and in water as a spray for the aerial parts. This material was used for three seasons and at varied strengths. The behavior of the foliage and fruit was noted carefully at frequent intervals during the period, but in no case were the treated vines better in foliage and fruit than the check vines.

Both the soil and subsoil of the knoll were compared as to physical composition with that from other parts of the same vineyard where the vines were unaffected. The soil over the knoll proved to be of a much finer texture with but few coarse particles, and apparently very deficient in organic matter. By reason of its elevation and lack of organic matter it is low in moisture content, except during wet seasons. Soils from the vicinity of normal vines was found to be of a much darker color, heavier and with much more coarse material. Chemical[4] analysis of the two varied types revealed no striking differences in nitrogen, phosphorus, potassium or calcium carbonate content. In two other affected vineyards the sub-soil is very similar to that whereon are found the badly diseased vines just cited.

Tests over a period of three years with the principal elements of fertility, nitrogen in nitrate of soda and dried blood, potassium in sulphate and muriate of potash, calcium oxid or calcium carbonate have not affected the degree of injury from the malady. As in the tests with sulphate of iron, vines noted in previous years as badly affected were marked, and the above elements applied, while others showing approximately the same extent of injury were left untreated. In these tests, as with the sulphate of iron, the control was judged from the appearance of the foliage and fruit on the treated and untreated vines. In either case the worst affected vines lost the larger percentage of their leaves some time before the ripening period, and as a result the fruit did not color nor acquire character. Much of the fruit "shelled" and thus was not harvested, that remaining being unfit even for the poorer wines.

[4] Analyses made by the Agronomy Department at Geneva.

HOW MAY THE ILL EFFECTS BE LESSENED?

Since the trouble now appears to be associated with the supply of soil moisture at critical periods, practices that result in the incorporation of considerable amounts of organic matter with the soil suggested themselves as possible correctives. Consequently it has been the aim at the experiment grounds to apply this principle as well as the several suggestions that follow. Observations have been made at the Station as to the effects of underdrainage upon the malady, while the manner of pruning as later advised is based upon practice in our vineyards.

The addition of organic matter may be accomplished by the use of relatively large amounts of strawy stable manure, turning down green manure crops annually and the utilization of straw, grasses and weeds from waste lands. It is possible, of course, to interrupt soil capillarity thru the use of excessive amounts of coarse materials, hence it is suggested that, when coarse materials are to be used, they be composted and later applied in a partially decomposed state.

With soils that do not allow of sufficient root development by reason of wetness, thoro tile drainage is of first consideration. That the vines may profit most from tiling, it should be done a few years previous to planting.

Soils that consist of a shallow, friable surface layer underlain by stiff, almost impervious clays should in addition to tiling be deeply sub-soiled before planting. Soils that will not admit of sub-soiling by reason of closely underlying rock layers should be entirely avoided for vineyard purposes. Where, for financial reasons, tiling is not to be done, more planting space should be given between the rows and the vines set at a greater distance in the row. This insures a wider lateral root range. The tendency for the past few years has been to closer planting on this soil type, with ill effects.

The importance of early spring plowing, followed by an immediate cultivation or discing, and tillage after each heavy rainfall has demonstrated its value. If the soil be one that can only be worked under the most favored conditions in the spring, it should be fall-plowed. We have found that the vineyard plowed in the fall can be disced or harrowed much earlier and easier in the spring than if the plowing is done in the spring.

Vines affected with the trouble should be more closely pruned than normal vines. In severe cases that have extended over some years with no apparent improvement, the vines should be cut back to the ground. It avails nothing to take out such vines and plant others in their places, as is ordinarily done, for the causes are in the soil and not in the vine. A vine reset in a soil that has favored the trouble is under greater adverse conditions for growth than the one removed and already partially established, as the competition of the vine roots for moisture and plant food is very keen, and the older vine with a partially established root system is in a position to get hold of these much more readily than the newly planted one, whose roots are not as yet in close relation to the soil.

If an affected vine fails to respond to the practices above outlined and its removal becomes necessary, it is far better to replace it by layering a cane from an adjacent healthy vine in the space vacated. In order that the cane thus utilized be held firmly in place and in contact with the soil while roots from it are striking, two small stakes or pegs are driven crossed, so that they hold the cane between them at the point where it is desired the vine shall root. From this point the cane is carried in an upright position above the ground level, where it is cut off so that two or three buds will project above the soil when the trench or hole is filled. By keeping the cane attached to the parent plant for two or three years, plant food elaborated by the older vine will be passed on to the layer while its roots are forming, and then when it is sufficiently well established the cane can be severed from the parent with no interruption in the growth processes. A layer thus made will live under adverse climatic and soil conditions fatal to a nursery vine. The practise of layering makes necessary the selection of desirable canes that are located at the extremities of the arms adjacent to the vacant positions. There should not be much difficulty on this score for, with the Chautauqua system of training, the better canes are in just these positions. Often the arm that is to carry the layering cane is selected two years preceding the actual layering.

The presence of many vines affected with the trouble appears at first hand to foreshadow the early end of a commercial vineyard, yet our observations on the Station grounds and elsewhere indicate that there is a gradual recovery under average vineyard care, while it is much more rapid as the various unfavorable influences are

corrected. As already stated, it is futile to pull out a vineyard seriously affected with the trouble, and reset within a year or two with the expectation of good results. The soil should have returned to it several crops of green-manures before the vines are again located. It is quite possible to grow annual crops successfully on the soils favoring the affection in the event of removal of vines by reason of it.

REPORT

ON

INSPECTION WORK.

W. H. Jordan, *Director.*

L. L. Van Slyke, *Chemist.*

†Rudolph J. Anderson, *Associate Chemist.*

A. W. Clark, *Associate Chemist.*

John C. Baker, *Associate Chemist.*

M. P. Sweeney, *Assistant Chemist.*

Otto McCreary, *Assistant Chemist.*

Richard F. Keeler, *Assistant Chemist.*

William F. Walsh, *Assistant Chemist.*

Walter L. Kulp, *Assistant Chemist.*

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† On leave, in war service.

REPORT ON INSPECTION WORK.

REPORT OF ANALYSES OF SAMPLES OF COMMERCIAL FERTILIZERS COLLECTED BY THE COMMISSIONER OF AGRICULTURE DURING 1918.

[Text of this Bulletin, No. 452, December, 1918, is omitted, since the data cease to have value before the Annual Report can be distributed.— W. H. JORDAN, *Director*.]

ANALYSES OF MATERIALS SOLD AS INSECTICIDES AND FUNGICIDES.

[Text of this Bulletin, No. 454, December, 1918, is omitted, as the data cease to have value before the Annual Report can be distributed.— W. H. JORDAN, *Director*.]

INSPECTION OF FEEDING STUFFS.

[The text of this Bulletin, No. 455, December, 1918, is omitted, as the data cease to have value before the Annual Report can be distributed.— W. H. JORDAN, *Director*.]

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APPENDIX.

POPULAR BULLETIN REPRINTS.

NEWER VARIETIES OF STRAWBERRIES.*

O. M. TAYLOR.

INTRODUCTION.

This report on strawberries sets forth the results of the tests of the introductions since the issue of Bulletin No. 401. The sixty-one varieties described do not include all that were grown. The standard commercial kinds have fruited each year and have been used as a basis of comparison. Cultural directions are omitted, as this subject is treated in detail in Circular No. 31. All varieties were grown in matted rows, and the selection of soil and the methods followed were as uniform as possible.

Source of varieties.— To avoid the possibility of reporting on plants not true to name the stock was obtained directly from the originator or introducer, if possible, and statements were secured from them in regard to the history of the variety. Past experience has shown that under such apparently favorable circumstances, errors occur and at times reports are received which are at variance with previous statements from the same persons. Plants of over fifty of the varieties came from originators or introducers. Definite statements were secured giving one or both parents of thirty-three varieties, while twenty-eight kinds are chance seedlings of unknown parentage.

Station seedlings.— During the past few years this Station has carried on extensive experiments in the breeding of fruits. The strawberry has not been neglected. Thousands of plants have been under observation. A few of these, after fruiting for several years, were considered worthy of more extended trial. In the spring of 1917 plants of eight kinds that had been named were distributed in different parts of the State for testing under varying soil and climatic conditions. It is not expected that they will all do as well elsewhere as on the Station grounds. After a thoro and extensive test, some of these seedlings may continue to make good records and if so, several growers located thruout the State should have

* **Reprint of Popular Bulletin No. 447, February, 1918. For Bulletin see p. 395.**

plants for sale. This Station has no more plants for distribution of these eight kinds. Full descriptions are included of these seedlings, all of which mature in early or late mid-season.

Plant-makers.— Over-crowding of plants is a common cause of unsatisfactory results. Some kinds like Angola, Frances Willard, Myrtle Murrell, Rewastico and Wildwood produce runners in such numbers that more distance should be given between rows and plants. Other varieties are shy plant-makers and if the ordinary distance is used, the ground is but poorly filled with plants and the yield is low altho the yield per plant may be high. The following twelve kinds have a tendency to produce comparatively few plants:

SHY PLANT PRODUCERS.

Addison	Benancie	*Minnesota No. 1017*
Advance	Friendship	Richmond
Alvin	Hustler	Standpat
Autumn King	J. B.	Todd

Plant-vigor.— Size of plant and sturdiness are relative terms and are influenced by character of soil, food-supply, temperature and rainfall, as well as by the variety itself. Among the strongest-growing kinds may be named Aurora, Edmund Wilson, Ford, *Morgan No. 21* and Wildwood.

Yield.— An unproductive variety is undesirable. Yield is a variable factor influenced by almost every condition of environment. Yet a variety, when all conditions appear ideal, may yield hundreds of quarts of fruit while some other variety under apparently identical conditions will produce thousands of quarts. During the past two years ample rainfall has prevented the usual reduction in yield by drought, but has caused losses at times by keeping foliage and fruit too wet, so it was impossible to remove the heavy yield in good condition. Seven varieties, Benancie, Joe Crampton, Jopp Favorite, Lady Corneille, Myrtle Murrell, Standpat and *Wittlinger No. 1* were uniformly unproductive, while the following nineteen kinds produced fruit in greatest abundance:

VERY PRODUCTIVE VARIETIES.

Allen No. 1	Eureka	Nellis Triumph
Angola	Ford	*Minnesota No. 3*
Athens	Friendship	*Minnesota No. 1017*
Chester	Gibson	Oregon
Collins	*Knight No. 1*	Rewastico
Eldorado	*Morgan No. 21*	Richmond
		Wildwood

Health.— Resistance to disease, when combined with other desirable qualities, is greatly to be desired. It is difficult to determine whether freedom from disease is an inherent quality or is due to lack of conditions which favor the spread of such troubles. Varieties may be healthy one season and show much disease a year later. Several years must elapse and the plants be grown under unfavorable conditions to determine their susceptibility to disease. During the period of this test the following ten varieties showed much injury from leaf-spot:

Varieties Susceptible to Leaf-Spot.

Alaska	Joe Crampton	Standpat
Charles I	McAlpine	Todd
Friendship	Myrtle Murrell	Warren
		Wildwood

Color of foliage.— Few varieties are characteristic in leaf-color. Rich soil and applications of stable manure or of nitrogenous fertilizers tend to produce a dark green color while lack of nitrogen, as well as conditions of poor drainage, is liable to result in lighter color. The color of foliage appeared lightest in Friendship, McAlpine, Marshall Improved and Myrtle Murrell, the darkest color being represented in Ford, La Bon, Rewastico and Warren.

Sex of plants.— The present-day tendency is to give preference to perfect-flowering or staminate varieties, not because they are more productive or the fruit of higher quality but because it is thus unnecessary to provide other varieties to be used as pollenizers. Only twelve kinds described in this bulletin are imperfect-flowering, while nearly fifty varieties have both stamens and pistils. The twelve varieties referred to are as follows:

Flowers Imperfect or Pistillate.

Addison	Angola	Kellogg Prize
Alden	Frances Willard	*Knight No. 1*
Allen No. 1	Hustler	*Morgan No. 21*
Alvin	J. B.	Todd

Season of bloom.— Blooming-periods of varieties usually receive little if any attention. It is useless, however, in localities subject to late frosts to attempt to use the varieties that bloom too early. Among the very earliest-blooming sorts are: Alvin, Campbell, Eureka and Wide-awake; sixteen other varieties bloomed early;

four varieties, Autumn King, Hustler, Jopp Favorite and Todd opened their flowers late and the latest of all were Ford and Pearl.

Fruit-stems.— Consideration of fruit-stems might seem at first of no importance, yet their length, thickness and position, have a bearing on the condition of the fruit at harvest time, and the widest variations may be found among the varieties. Conditions of growth, however, may modify the fruit-stems so that these characters are not entirely constant but vary somewhat with the season. Alaska, Alvin, Collins, Ford and *Morgan No. 21* produced very long fruit-stems while those of Charles I, Minnetonka, Premier and Standpat were very short; fruit-stems of Frances Willard, Pearl, Rewastico and Todd were very thick; those of Advance, Autumn King, Collins, Joe Crampton, McAlpine, Myrtle Murrell, Oregon, Standpat, Wide-awake and Wildwood were slender; nineteen varieties produced erect fruit-stems and twenty-three varieties semi-erect to prostrate.

Calyx-characters.— There are usually marked variations in size, position and color of the calyx among varieties, altho some kinds are quite variable in the berries of the same variety. Edmund Wilson, Ford and *Morgan No. 21* developed a calyx of largest size; varieties with a small calyx are represented by Alvin, Argyle, Ashton, Autumn King, Charles I, Eldorado, Standpat and Wide-awake. The position of the calyx is variable; sometimes it is perched on a distinct neck, at other times attached directly to the flat base of the berry, and in some varieties it is sunken deeply in the surface. The calyx of thirty-two varieties was more or less raised, while at least twelve kinds were characterized by the sunken calyx. Attractive appearance of calyx is desirable but here again there are variations, some being uniformly bright, attractive green, others dull, dingy green and at times disease destroys the naturally handsome color. Eleven varieties were noted for the dull, unattractive color of calyx.

Position of seeds.— The position of the seeds in relation to the surface of the berry is usually of but little concern to the strawberry grower, yet it is a character that should not be altogether ignored. They may be characteristically raised above the surface as in the case of Advance and of twenty-four other varieties or the seeds may be deeply sunken in the fleshy surface, as in the case of nineteen kinds. Raised seeds protect the surface from being bruised

and such berries usually ship well, altho in some varieties the numerous, raised seeds give an unattractive appearance, especially with the smaller berries.

Season of ripening.— The time of ripening referred to in this bulletin is the June and early July period and has nothing to do with the "fall-bearing" season, although several varieties are described which characteristically produce their fruit during the fall months. Such varieties were given the same cultural treatment as the other kinds, and this must be borne in mind in interpreting results.

The ripening-season is of great importance. In some localities only the earlier varieties are profitable while in other markets the demand is for late-ripening kinds. In this report the season has been divided into very early, medium early, early mid-season, late mid-season, late and very late. The seasons are overlapping and to make any sort of division, arbitrary dates must be fixed with but scant leeway between the close of one season and the beginning of the next.

VERY EARLY	MEDIUM EARLY	LATE	VERY LATE
Campbell	Advance	Alvin	Abundance
Eureka	Charles I	Autumn King	Ford
Richmond	Eldorado	Hustler	J. B.
	John H. Cook	Kellogg Prize	Joe Crampton
	La Bon	*Knight No. 1*	Jopp Favorite
	Lady Corneille	McAlpine	Pearl
	Marshall Improved	Rewastico	Todd
	Morgan No. 21		Warren
	Minnesota No. 3		Wildwood
	Oregon		
	Premier		
	Wide-awake		

Size of fruit.— Reasonable size is essential either for home use or for commercial purposes. It is dependent partly on the habit of the variety but is influenced largely by the amount of moisture available at ripening time. Berries may be too large as well as too small. Most varieties are intermediate in size. Addison, Ford, Jopp Favorite, Magic Gem, *Morgan No. 21* and Pearl produced fruit of largest size while at the other extreme were Minnetonka, Myrtle Murrell, Standpat and Wildwood. The following varieties retained good size fairly well thruout the season: Arcade, Argyle, Aurora, Charles I, Collins, Edmund Wilson, Frances Willard, Jopp Favorite, Magic Gem, Nellis Triumph, Oregon, Pearl, Warren. Most kinds dropped rapidly in size after the first two pickings.

Shape of fruit.— Shape of fruit is not usually of much concern in varieties of strawberries. There are a few, however, the fruit of which is often malformed or misshapen. Roundish-conic berries usually look better and pack to better advantage than those long or wedge-shaped. Over thirty of the varieties described were conic or roundish-conic; less than half a dozen were roundish; one, the La Bon, was inclined to be oblate; twenty-five kinds were slightly wedge-shaped; five kinds, *Allen No. 1*, Collins, Eureka, John H. Cook and Jopp Favorite were decidedly wedge-shaped; while the long-conic berries were represented by Alaska, Aurora, Frances Willard, Friendship, Greek, Myrtle Murrell, Premier, Richmond and Woodrow.

Color of fruit.— Undesirable color will disqualify any variety. The appearance must be fairly attractive. The berries may be light red, medium red or dark red yet be bright and glossy, giving a handsome appearance. A dull, dingy or faded color is undesirable whether the prevailing color be light or dark. The fruit of fourteen varieties was light red, about the same number medium red, with over a dozen dark red, the darkest of all being Wide-awake. Twenty varieties were dull.

Color of flesh.— The flesh-color depends on the variety and also to some extent on the stage of ripeness. Many berries with light red flesh, whitish at the center, become darker red thruout when fully mature, making it difficult to distinguish those which are characteristically whitish at the center. This character is noted in the description of varieties. Fifteen varieties produced whitish-centered berries, nearly thirty kinds medium to dark red, and twelve kinds light red.

Juiciness of flesh.— The relative amount of juice in the flesh is quite constant. No amount of external moisture will make up for a natural dryness of texture. A dry berry or one lacking in juiciness will continue to be dry, rain or shine. Ten varieties are characterized as very juicy, over thirty as juicy and more than a dozen are lacking in juiciness or are but medium juicy.

Firmness of berry.— Solidity of texture is of great importance. A soft berry is worthless for shipment to any distance no matter how desirable in size, color or flavor, altho this character is not so important for home use. It, however, is always desirable, for lack of firmness almost always results in a "mussy" condition of the

fruit. Among the varieties under discussion, twenty-seven were rated as firm, fifteen as lacking more or less in firmness and the following ten varieties as very firm:

BERRIES VERY FIRM.

Allen No. 1	Magic Gem	*Minnesota No. 1017*
Chester	Minnetonka	Pearl
Greek	*Morgan No. 21*	Wide-awake
		Woodrow

Flavor.— One of the most difficult characters to determine is that of flavor. There is often more or less lack of uniformity in flavor between berries of the same variety, berries ripening in a dry or a wet period, the particular stage of ripeness reached and also a variation in personal likes and dislikes. What is pleasant to one palate may be quite disagreeable to another. There is, however, such a wide variation in flavors among the different varieties that some kind may be found acceptable to almost any palate. Over forty of the varieties may be designated as subacid or slightly sprightly while at the extremes are found seven varieties, Collins, Friendship, Greek, Lady Corneille, *Minnesota No. 1017*, Rewastico and Wide-awake distinctly tart and such varieties as Alaska, Argyle, Chester, Ford, *Knight No. 1*, Myrtle Murrell and *Wittlinger No. 1* among the list of those sweetest. Argyle, Gibson and Magic Gem are among the highest-flavored kinds.

Quality.— The most important rating is that of quality. By quality is meant the sum of all the characters that make the berries desirable to the taste. What varieties may be considered best or poorest in quality? Here again the personal element enters, for standards of judgment differ and what is good in the sight of one person may be moved either forward or backward by some other judge. Three varieties, Argyle, Magic Gem and *Morgan No. 21* were rated very good, over thirty varieties good, eighteen kinds fair and eight varieties distinctly poor.

Promising varieties.— In the determination of what varieties should be recommended for testing, all factors must be considered and each should receive its relative value. It must be remembered that all the varieties fruited on a heavy, cold, clay loam, which is not considered ideal soil for the strawberry. Doubtless on a lighter, warmer soil some of these varieties would have made a better record. All the most promising kinds have their defects as well as their good

points. The following list is therefore only suggestive of those varieties which have made the best showing for one or more years under the local climatic and soil-conditions at this Station. More than half the varieties are in the discard list. The eight seedlings originating at this Station are of course included among those of promise, leaving nine other kinds considered of merit, with eight varieties on the doubtful list, which on account of an unusually fine record along one or more important characters should be further tested despite certain defects.

DESIRABLE VARIETIES.

Addison	**Campbell**	**Joe (Joe Johnson)**
Alden	**Eldorado**	(?) **Kellogg Prize**
Angola	(?) **Eureka**	**Magic Gem**
Arcade	**Ford**	***Morgan No. 21***
Argyle	(?) **Frances Willard**	(?) **Minnesota No. 3**
Ashton	**Gibson**	**Oregon**
Athens	(?) **Hustler**	**Pearl**
Aurora	(?) **John H. Cook**	(?) **Warren**
		(?) **Wide-awake**

[Detailed descriptions of varieties follow in the complete edition of this bulletin, which may be obtained on request.]

CONTROL OF BACTERIA IN MILKING MACHINES.*

F. H. HALL.

Machines of service in war-time dairying. Previous to the war, the scarcity of labor turned the attention of dairymen toward the milking machine as an aid in economical production. Under the present intensified demand for labor and its high cost, the demand for machines would be still greater could herd owners feel that they can lessen labor charges by using milking machines and readily produce milk of satisfactory bacterial quality with them. So far as mere drawing of milk is concerned, in herds of considerable size and in careful hands, there is no question that cows may be more economically milked by machine than by hand; but when to this cost it may be necessary to add more labor expense to keep the machines in satisfactory bacterial condition and there is a common doubt whether machines under ordinary conditions can be made to furnish milk with as few germs as that drawn by hand, the problem becomes more complex. The use of machines is increasing gradually in the State since a recent agricultural census reported more than 4600 of them on the farms; but too often the report is heard that owners abandon the use of the machines after trial for two or three years. Part of these unsuccessful attempts are doubtless due to defects in the machines, as yet not wholly corrected; but probably more abandonments result from finding that the machines are difficult to keep clean by ordinary methods.

Early Station studies. The Station has been continuously studying some phase of the milking machine problem since 1906, when a Globe machine was used for a short time, to be discarded for very evident defects. This was succeeded in our stables by the Burrell-Lawrence-Kennedy milker; and with this machine in its modified and improved forms as developed during the ten years, all subsequent experiments at the Station have been made.

*** This is a brief review of Popular Bulletin No. 450, July, 1918, of this Station on Milking Machines: III. As a Source of Bacteria in Milk; IV. Methods of Maintaining in a Bacteria-Free Condition, by G. L. A. Ruehle, Robert S. Breed, and George A. Smith. Anyone especially interested in the detailed account of the investigations will be furnished, on request, with a copy of the complete bulletin. Names of those who so request will be placed on the Station mailing list to receive future bulletins as issued, either popular or complete edition as desired. For Bulletin see p. 31.**

In our first milking machine bulletin issued (No. 317), tests of a 10 per ct. brine solution as an antiseptic for the rubber parts showed good results; and with certain modifications of the air filters on the machines and careful handling of the apparatus, the bacteria in the milk were almost always kept down to 10,000 or less per cubic centimeter. This bulletin emphasized the necessity of avoiding carelessness in handling, but held that " when machines of the better type are run properly they will deliver milk of low germ content." In a later bulletin (No. 353), it was stated that "the milking machine is of interest mainly because of the labor problem. Using two machines one man can milk fifty cows." The influence of the machine method of milking upon the flow of milk was too small to be detected in a series of tests lasting over four year and including 71 lactation periods; all of the cows milked well with the machine when provided with properly fitting teat-cups, and two cows that were failures with hand milking were milked successfully by the machine. " Machine milking has proved practicable. The problem now is to develop the machines along helpful lines and to learn how to handle them most efficiently." This was the final conclusion relative to Station experience with the machines up to 1912. The present bulletin discusses a great amount of work done since that time in the effort to learn how to so handle them as to simply and easily produce milk containing few bacteria.

These studies necessary.

That such added studies were necessary is plainly shown by the great difference in results secured at the Station during the past ten years, and the results observed by our bacteriologists on dairy farms near the Station, or reported by other investigators in securing milk of low germ content. Under our Station conditions, with machines thoroly cleansed, with the metal parts scalded or steamed, and with the rubber parts well rinsed after each milking, vigorously cleansed once per week and kept in carefully prepared antiseptic solutions between milkings, practically all of the examinations of the milk have given low germ counts, usually as good as or better than required for certified milk. About two dozen reports of experiment stations or other investigators were found dealing with the bacterial quality of milk in machine tests. In many cases the comparisons were between hand-drawn and machine-drawn samples, in others between milk drawn with and without special precautions to secure good conditions of the machines and tubes, and in others to show the effect of different antiseptic solutions in which the teat-cups and tubes were kept between milkings.

In the reported tests, whether made at experiment stations or similar research institutions, or on ordinary or commercial dairy farms, there is practically unanimous agreement that the suction type of milking machines must be cared for by special methods of cleaning if they are to be maintained in a sufficiently germ-free

condition to yield milk with as few germs as that obtained by careful hand milking. Under practical conditions where dairymen use no machines, only methods similar to those they would employ in cleaning simple metal utensils, such as pails, strainers and the like, the investigators have frequently drawn milk from the machines with millions of germs per cubic centimeter; and where steam was available for sterilizing the pails and metal parts of the machines, the counts, tho lower, have not been satisfactory; and even at high grade farms, as at colleges and stations, the counts from machine-drawn milk have usually been higher than from hand-drawn milk from the same stables. But where bacteriological tests have been made and special methods of caring for the machines developed, several investigators have found, as at this Station, that as good or better results can be secured than by hand milking. In three such cases,— at the Wisconsin and Kentucky Stations, and in the certified milk supply of Brooklyn,— where the tests have been extensive, the machine-drawn milk has been found very satisfactory in germ content.

In these studies different factors have been considered important in controlling the bacteria counts of machine-drawn milk: Most investigators have given first place to the difficulty of keeping the rubber tubes and teat-cups free from germs between milkings and have called attention to various antiseptic materials or antiseptic measures for aiding this purpose; stable air has been considered a most important source of germs, and its entrance into the pail when the vacuum relief valve was opened at the end of milking, the cause of high germ counts which were favorably modified by various types of filters; the continuous entrance of air during milking in machines of the B-L-K type has also been mentioned as a factor; other students have held that condensation water from the metal suction pipes is a more important source of bacteria than the air, and that the filters have been more important as moisture retainers than as removers of bacteria from the air; still other investigators call attention to the vacuum-cleaner effect of the teat-cups when dropped during the operation of the machines and think such accidents the cause of many high counts; it is believed by some, also, that the bacteria may be drawn by the suction from the outer surfaces of the udder or washed by the milk from the outer surfaces of the teats.

Because of the somewhat contradictory ideas held in regard to the sources of the bacteria, and the need for exact knowledge before remedial measures could be successfully applied, the first step taken in the present studies was to make an intensive and detailed study of the B-L-K machines in use at the Station. In these the contamination from the udder or teats has been eliminated by the method of "milking," but the other points mentioned above have been considered, with special reference to the effect each may have upon the germ content of the milk, and with careful study of the means by

which the entrance of bacteria into the milk from any of these sources may be prevented or greatly reduced.

Methods of study.

In earlier Station studies, as in those of most other workers along these lines, counts of the bacteria were made from the milk as drawn from the cow; but this involves danger of many variable factors. The milk from the udder contains bacteria, in some cows normally many, in others few, but in both cases liable to change in numbers from day to day; and germs from the surface of the teats and udder might also be drawn into the machine in varying numbers.

ARTIFICIAL UDDER USED IN EXPERIMENTAL WORK.

Accordingly for the cow, there was substituted an artificial udder (see figure) consisting of a covered metal can with four faucets projecting from the bottom on which the teat-cups could be slipped. As this apparatus could be readily sterilized and sterile water placed in and "milked" from it, the danger of accidental contamination was greatly reduced; and the bacteria found in the water thus "milked" could well be ascribed to the whole milking machine or to the parts thru which it was drawn. Five liters (about five quarts) of sterile water were used for each milking which took from three to four minutes, and the bacteria counted in cubic centimeter samples which were treated by standard bacteriological methods of taking, plating, incubating and counting.

Under supervision of the Dairy Expert, the care of the machines at the barn and their cleansing at the dairy room have been, from almost the first, in charge of the regular dairy attendants, the two men principally responsible remaining unchanged during the entire time.

The routine of cleaning has been as follows: Immediately after each milking a large pailful of clean cold water was drawn into each machine thru the teat-cups, followed by a pailful of hot soda water and a final pailful of clean hot water. After the evening milking the pails of the machines were emptied, rinsed with cold water and left until morning; but after each morning milking the pails and heads of the machines were sent to the dairy where they were more thoroly washed and all metal parts but the pulsator piston steamed for a few minutes in a steam chest. The covers were then placed on the

pails and the machines stood in the dairy room until the evening milking. During the earlier experimental work the teat-cups were kept in a brine solution, but during the later work other antiseptic solutions were also tried. On Tuesday of each week these teat-cups and tubes were sent to the dairy and scrubbed with spiral brushes and warm soda solution and again returned to the antiseptic solution.

"Milking" tests at Station.

The first series of tests using the artificial udder was to ascertain the efficacy of the treatment outlined above on the germ content of the machines. Twenty-two tests were made in March, May and June, 1916, ten of them with four successive "milkings" of sterile water thru a machine, ten others with two "milkings," and two with but a single milking. The results proved that the machines were well freed of germs by the washings, steamings and use of antiseptic solutions (a solution of chloride of lime in water having been used in this case). The germ counts rose as high as 10,000 at only two tests and averaged from about 1400 to a little over 2000.

In a later series, still without change in the method of cleaning the machines and with chloride of lime as an antiseptic, an attempt was made to find what part or parts of the apparatus were the source of the germs. By introducing a sampling device between the teat-cup tubes and the head of the machine, and another just below the head of the machine, separate portions of the water were taken at these points as well as from the body of the pail. These tests were made in mid-summer, and gave somewhat larger counts than the first series, averaging from 2800 to more than 8000 for the entire machine. The tests made to discover the source of the germs were somewhat disappointing as they gave irregular results, some of which may have been due to faulty sampling of the water as it passed thru the tubes. The indications were, however. that more than one part of the machine harbored germs, tho never in large numbers since the final counts, while higher than before, were still low.

Subsequently, an attempt was made to secure complete sterilization of one of the machines, the Assistant Bacteriologist himself cleaning and handling the parts, separating the rubber tubes and metal parts completely and sterilizing the rubber in a very strong chloride of lime solution, while the metal parts were steamed, all except the pail being held under 15 pounds steam pressure for fifteen minutes. In many milkings made with such carefully handled machines, the germ content of the water in the "udder" and that taken from the machine differed but slightly, both being practically sterile, a result which showed that all of the sources of bacteria had been found and placed under control.

Condensation water from vacuum pipes. Certain investigators have found that the condensation water returning from the pipes when the vacuum was relieved in the pail at the end of milking brought with it many germs. So the manufacturers of the B-L-K machines have in later models substituted for the cotton filter on the head of the pails a suction trap which retains this water. The Station machines in use were fitted with this trap; but because some germ counts were obtained which were difficult to explain, many tests were made to determine its thoroness of operation. Very severe tests failed to show that even a trace of moisture from the pipes passed back thru the trap into the machine. That it served a very useful purpose was proved by substituting an older head with the cotton filter, " milking " sterile water thru the machines and measuring the effect on the water in the pail, all other known sources of bacteria being placed under control. By using a glass jar in place of the ordinary machine pail, it could be plainly seen that several teaspoonsful of condensation water might be sucked thru the cotton when the vacuum was relieved; and the counts showed that this water was full of bacteria and increased the number in the samples taken from the water in the glass jar some hundred or even thousand fold over those found when the vacuum was broken thru the teat-cups, thus avoiding the " sucking back " effect.

Dust in stable air. It having been claimed by several previous investigators that many germs entered with the air during and at the close of milking, and cotton filters having been recommended for use at the points where the air enters, tests were made to determine the number of germs thus entering. At the same time, the efficiency of the cotton filters was tested. By attaching a device for filtering the air at the two openings where air enters the B-L-K machines, all of the germs in the air were retained on fine sand. This sand was then examined by the usual methods of analysis and the number of organisms in the air computed. Altogether 54 tests were made. In this way it was determined that between 10 and 9800 germs were drawn in with the five liters of sterile water from the air which entered at the teat-cup connector during artificial milking; while between 6100 and 157,000 germs were drawn in from the dustier air near the cows during actual milking.

Opening the vacuum relief valve on the head of the machine to relieve the vacuum at the end of milking was found to draw between 20 and 1750 germs into the pail after artificial milking, or between 40 and 11,400 after actual milking, 24 trials being made in the former and 33 in the latter case. While these numbers appear to be significant in size, yet when they are transformed to the basis of a cubic centimeter of milk, the standard unit of measurement, it is found that these numbers are relatively insignificant. Under the

worst conditions noted, the air contributed less than 37 germs per cubic centimeter, while the average numbers added from the air was less than ten per c.c.

As several investigators have placed much emphasis upon the use of cotton filters to prevent the entrance of germs from the air, 14 tests were made under artificial and nine under actual milking conditions to determine the efficiency of cotton filters used in the teat-cup connectors. Fourteen tests were also made of the efficiency of the filters used in the vacuum relief valves on the head of the pails. All of these indicated that the cotton removed a little dust and about two-thirds of the germs. Since, however, as already explained, the total number of germs from the air is so small as to be scarcely detectable when mingled with the much larger numbers of germs in the milk from other sources, the use of these filters is a relatively unimportant matter.

Dropping teat-cups during milking. Several investigators have attributed unexpected increases in the germ content of machine-drawn milk coincident with accidental dropping of the teat-cups to the floor, to the bacteria drawn in with dirt under such circumstances. So far as known, however, no previous tests have been made to determine the relative importance of this source of bacteria. In making the tests, the machines were completely sterilized by the methods previously shown to be efficient and five liters of sterile water drawn into them as before. As a check upon the efficiency of the sterilization, the first milking in each series of four milkings was performed as usual; but during the second milking the teat-cups were held for 30 seconds vertically over and lightly touching the bedding. Without cleaning the teat-cups unless this was made necessary by the dirt clogging them, a third milking was carried out, followed by a fourth in which the teat-cups were again dropped to the floor and allowed to lie on their sides for 15 seconds.

The results showed that the machines were practically sterile when the experiments were started, and that the bacteria sucked in with the dirt were numerous enough to cause counts between 60 and 24,400 per cubic centimeter. However, only four of the 15 counts exceeded 10,000 and none reached the size previously thought to be obtainable from this source. The largest of the counts were secured under very bad and dirty conditions, as is shown by the fact that in two cases where the dirt was filtered out of the water and dried it was found to weigh .014 and .026 grams per liter.

Conclusions. Excluding consideration of the teat-cups and rubber tubes for the moment, these experiments show that the comparatively small number of germs derived in the water drawn into the Station machines came from several places; and that the relative importance of each as

a source of germs varied with the conditions present. Under the conditions of the earlier Station studies reported in Bulletin No. 317, where machines were used in which there was a large cotton filter placed at the junction between the connecting hose and the head of the machine, it is probable that at times quite large numbers of germs entered the pails with the condensation water at the close of milking. Since the use of an efficient trap on the later models has brought the matter of contamination from this source under control, it is probable that the condensation water was the source of the high numbers occasionally obtained in the earlier work when there was no observed occasion for them.

" Milking " tests at dairy farms.

While the experiments thus far discussed were in progress with the Station machines, observations were also being made upon milking machines of the B-L-K, Hinman and Empire types in use on 10 dairy farms in the neighborhood of the Station. While it was not possible to make these tests under perfectly controlled conditions, analyses were made by our bacteriologists which showed the amount of contamination which milk would receive if drawn with these machines, cleaned and cared for, as they were, by practical dairymen. In making these tests sterile water and the other necessary supplies were prepared in the Station laboratory and taken to the farm where the tests were to be made. After the machines were prepared by the dairyman in the regular way for the afternoon milking, one or two successive " milkings " were performed in which five liters of water were drawn from the artificial udder. In the case of the B-L-K and Hinman machines, samples were taken not only from the pail at the close of milking but also of the water as it entered the pail, the analytical results showing whether the principal contamination came from the teat-cups and head or whether it came from the pail. The antiseptic solution in use on these farms was found to be either chloride of lime alone, or in combination with brine.

The germ content of the water in the pails after being drawn thru the machines was found to be highly variable. In 13 instances the counts were less than 10,000 and compared well with those obtained at the Station. In 16 cases, however, the counts were in excess of this number tho still less than 1,000,000, while in 8 cases the counts exceeded 1,000,000, reaching a maximum of 59,300,000 in one instance. The most significant thing, however, was that in each instance where samples were taken before the water entered the pail, it was found to have practically the same germ content as it had after it reached the pail, showing that the majority of the bacteria were added to the water in its passage thru the teat-cups and head of the machines. Good and bad results were obtained with all three types of machines, indicating that it was the care given the machines rather than the construction of the machines

which was at fault. Samp.es taken of the antiseptic solutions showed that the strength of the available chlorine in many of the solutions was much too low to be effective, tho relatively high counts were obtained in some instances where brine and chloride were both in use and the solution was apparently in good condition. In all cases where the excessively high counts were obtained, an examination of the separate parts of the teat-cups and tubes showed that these were not kept in as cleanly condition as were the same parts at the Station.

Hand-drawn vs. machine-drawn milk.

In connection with our work upon the milk supply of the City of Geneva, reported in a preliminary way in Bulletin No. 443, the use of machines on the dairy farms producing milk for the City was found to exert a generally unfavorable influence upon the germ content of the milk. Still more extended data of the same sort is presented in the present bulletin. It was found that in one list of 44 dairymen none of the six men supplying machine-drawn milk was in the first third of the list. An examination of 3013 cans of milk from these six dairymen showed them to have approximately the same germ content as 3051 cans of milk from the nine poorest dairymen sending hand-drawn milk. On six farms where direct comparisons were possible, only two dairymen produced milk of as low germ content during the period when the machines were in use as when the milk was hand-drawn; while the introduction of machine milking did not improve the germ content of the milk in any case. However, in a second list of 36 dairymen, one of the users of a machine, who stood near the head of the list when he practised hand milking, maintained an equally high rank after he began using a machine. On the farms where the results were the poorest, the herds were large and the milking was done by hired labor of an indifferent character.

Antiseptic solutions.

Our bacteriologists, as well as other investigators, having found that the rubber teat-cups and tubes completely overshadow all other possible sources of bacteria, have made extended tests to determine which of several suggested antiseptic solutions are satisfactory for use on these rubber parts. The antiseptic solutions or antiseptic procedures which have been tested are (1) brine, (2) solutions of chloride of lime, (3) a combination of brine and chloride of lime, (4) lime water, (5) cold running water, and (6) a proprietary germicide sold under the trade name of "montanin." Each of these has been used for weeks, or more commonly months, in our dairy, and the efficiency of each as a means of keeping the tubes free from germs has been tested by "milking" tests carried out as previously described. All sources of germs

other than the stable air and the teat-cups and tubes were controlled by the measures previously tested and found effective. Contamination from the air was reduced to a negligible minimum by doing the work under practically dust free conditions.

Brine. Brine solutions varying in strength from 10 to 13 per ct. were in use from 1910 to 1916 and nearly 500 analyses were made of this solution in order to determine the amount and kind of bacteria present under the varying conditions. These showed that the brine was not free from bacteria, and that at times very large numbers were present. The kinds of bacteria present, however, were those adapted to life in salt brines; and failed to grow, or grew poorly, under conditions favorable to ordinary bacteria. This fact explains why it is that in spite of the fact that the tubes contain bacteria in appreciable numbers, strong brines are useful as a means of keeping the rubber tubes in fit condition for use when milk of low germ content is to be produced. Even tho brine bacteria get into the milk they have no effect on it and soon die.

Chloride of lime. In using chloride of lime (bleaching powder) solutions our bacteriologists found that they could completely sterilize the teat-cups and tubes provided these were completely separated into their component parts, thoroly cleansed and then placed in a strong solution of the antiseptic solution. This procedure is not practicable, however, even on certified farms nor is it necessary in order to secure excellent results. In a nine months test extending from December, 1916, to August, 1917, the machines were washed and cared for by the ordinary dairy attendants using the methods of cleaning the machines previously described, and keeping the teat-cups and tubes in a solution of chloride of lime between milkings. This solution was kept in a 25 gallon crock, and was prepared by adding a pint of a stock solution of chloride of lime to the jar full of water twice per week. The stock solution was kept in a smaller glass jar, and was prepared by adding the contents of one 12-ounce can of commercial chloride of lime to one gallon of water. After stirring thoroly, the white precipitate was allowed to settle, leaving a clear, greenish colored liquid. Only this liquid was added to the larger jar, tho no harm would have resulted if the white powder in the bottom of the jar had been used as well.

The results of 66 "milkings" of sterile water made before June 1, thru tubes kept in this solution, showed excellent results, only one of the germ counts exceeding 100 and that one being only 157. As soon as the warm weather started, however, the counts increased until out of the 36 trials made, 29 gave counts in excess of 1000 and 17 exceeded 10,000, the highest being 180,000. Supplementary tests were made to determine the cause of this increase and it was

found that the chloride of lime lost its strength so rapidly in the warm solutions that the interiors of the rubber tubes were not sterilized. This explained also why many of the highly advertised germicidal solutions advocated for use on teat-cups and tubes have failed to give satisfaction under practical conditions. The majority of these are either ordinary chloride of lime (calcium hypochlorite) in solution, or are the closely related but more expensive sodium hypochlorite.

Brine and chloride of lime. Other investigators have previously suggested that the good qualities of both brine and chloride of lime could be retained in a mixed solution and that their weaknesses offset each other. Consequently during six months, extending from August, 1917, to January, 1918, an antiseptic solution was used in the crock consisting of a saturated brine to which a quart of the stock solution of chloride of lime was added twice per week as before. In order to make the test severe, summer conditions were maintained by keeping the crock in a warm place. Analyses made under these circumstances showed that the brine was completely sterilized by the chloride of lime, and that while the chloride of lime lost its strength rapidly in the warm solutions, the presence of the sterile brine prevented the development of bacteria in the tubes.

During the six months, 76 trials were made in which sterile water was "milked" thru the tubes into the machines. The greatest increase in germ count noted was only 1920, this being the only count in excess of 1000. In the majority of instances the bacterial counts were so small that the increases found could not have been detected with any certainty if the analyses had been made from milk drawn in actual milking.

These results show the combined solution to be more effective in its action than is either solution used separately; and the results secured where the cleanliness of the tubes is maintained, are as perfect as can be desired.

Lime water. Other experiment stations and many practical dairymen have reported good results from using lime water prepared by slaking fresh lime. Accordingly tubes were kept in a saturated lime water solution from August to December, 1917. Summer conditions were maintained as before by keeping the crock in a warm place. Sixty-three trials were made where sterile water was "milked" thru the tubes. The number of bacteria found in the water was low in every case, tho slightly larger counts were secured than in the previous series of tests. In seven instances only was the count in excess of 1000, the largest being 2270. These results confirm the findings of others and show that lime water may be successfully used to keep the tubes in a satisfactory condition.

Other solutions tested. It having been reported that dairymen were getting good results by immersing their teat-cups and tubes in cold running water, and that the practice was being introduced into New York State, our bacteriologists made a test of this method also. The crock was placed where running water from the city water supply could pass thru it at a rate of about 12 gallons per hour. At the time the experiment was started in April, 1917, the temperature of this water was 43° F., but it gradually became warmer as the summer approached until it was 68° F. in August. Seventy-nine "milking" trials were made during this time and it was found that excellent results were secured so long as the temperature of the water was less than 62° F. In no case was the count in excess of 400. But as soon as the water became warmer than 62° F. all counts were large, varying between 8000 and 53,000. The results indicate that the cold temperature was the essential factor for success and suggest that refrigeration of the tubes might accomplish the same purpose. The tubes and jar presented a more cleanly appearance than where antiseptic solutions were used and the whole procedure was so simple that the dairy attendants were much disappointed when the practice was discontinued.

Because of its use on some of the certified dairies of the State, and because of its entirely different chemical nature from the other solutions tested, montanin, a proprietary germicide, was included in the series of tests made by our bacteriologists. Since, however, it was found to be unsatisfactory when carelessly used, and since many dairymen are known to be careless in rinsing their machines, this solution is not recommended for general use.

Recommended antiseptic solutions. The results of this work have shown that there are several entirely satisfactory solutions which can be used to keep the teat-cups and tubes free from germs, *provided they are properly and intelligently used.* Some of these are cheaper than others, are more convenient to use, or are more desirable for other reasons. The solution which we now use and which we recommend for general use is a saturated brine to which is added chloride of lime at least once a week and preferably twice per week. The chloride of lime keeps the brine sterile and aids the brine in keeping the tubes free from bacteria. The observations made by our bacteriologists on neighboring dairy farms show, however, that good results will not be secured with this solution unless the teat-cups and tubes are kept thoroly clean at all times.

Cleaning of teat-cups and tubes. As has been stated, it is our custom not only to copiously rinse the machines successively with cold water, with hot soda water, and clean hot water after each milking, but to steam the metal parts daily and once a week to take the teat-cups

and tubes completely apart and give each part a thoro cleansing. In order to determine whether this weekly cleansing was sufficient to maintain the tubes in a germ-free condition, 29 comparisons were made between the condition of the machines on the day before (Monday) and the day on which (Tuesday) the machines were cleaned. The net result of these tests was to show that our machines were as free from bacteria on Mondays as on Tuesdays. It is necessary, however, to practise this weekly cleaning if the tubes are to be kept clean and bright, as there is a small accumulation of sterile dirt in them each week which may in time be sufficient to afford protection to the bacteria.

Where the teat-cups and tubes are coated with germs when first used, it is to be expected that these will be gradually dislodged as milking progresses. The results of 81 series of milkings, where the water drawn thru the tubes was sampled after each of four successive milkings, showed that while there was a slight diminution in numbers as milking proceeded, yet this was not large if the original number of germs present was small. However, in 16 series of milkings in which the original counts were in excess of 1000, there was a constant tho not rapid diminution in numbers during the successive milkings, the counts from the fourth milking averaging 9000 as contrasted with an average of 27,000 for the first milking.

Conclusions. These findings corroborate the general impression that milking machines very readily become so seeded with bacteria that all of the milk drawn thru them contains large numbers of bacteria. Under bad conditions machines may become one of the most prolific sources of bacteria with which fresh milk ordinarily comes in contact. On the other hand these analyses show without any possibility of doubt that milking machines may be so cared for as to make them practically free from bacteria of all kinds, making it possible to draw milk by machine which contains no bacteria other than those originally present in the udder or on the teats of the cow. While extreme precautions are necessary in order to accomplish a result as perfect as this, it is possible for any dairyman by the intelligent use of simple and practicable means of cleaning and caring for the machines to secure results as satisfactory as are those obtained where cleanly hand milking is practised. The care of the machines should include washing, scalding and thoro drying of the metal pails and heads of the machines, the immersion of the teat-cups and tubes in a mixture of brine and chloride of lime between milkings, combined with methods of cleansing the tubes which maintain them in a sufficiently clean condition to allow the antiseptic solutions to come into intimate contact with the bacteria.

LEAF-HOPPERS INJURIOUS TO APPLE TREES.*

F. H. LATHROP.

Leaf-hoppers important apple pests. Serious injury to nursery and orchard plantings in New York has been observed during recent years to result from attacks of three species of insects known as leaf-hoppers. These tiny creatures resemble minute grasshoppers, scarcely more than one-eighth of an inch in length. They spend most of the time on the undersides of the leaves sucking the juices from the plants. When the leaves are disturbed the young leaf-hoppers scurry away, dodging quickly out of sight, while the adults fly swiftly to a place of safety.

The loss of sap which these pests consume is detrimental to the infested trees, but far more damage is done by the curling of the leaves and the destruction of the green substance of the foliage. Incidental winter killing of injured tissues in many cases greatly aggravates the damage done by certain species.

Relation to fire-blight. Another source of danger is the relation of the leaf-hoppers to plant diseases. Field observations have shown that the prevalence of fire-blight may be associated with the presence of leaf-hoppers and other sucking insects. The habits of leaf-hoppers would seem to make them especially capable agents for the transmission of plant diseases, and experiments conducted at this Station have demonstrated that the species popularly known as the apple leaf-hopper may carry fire-blight from diseased to healthy tissues. It is not improbable that the other species are equally guilty.

The apple leaf-hopper. This species (*Empoasca mali*) is of a bright green color. It attacks the tender, rapidly growing terminal shoots, and it is perhaps for this reason that the species shows a marked preference for young, growing trees. The presence of this species in numbers is at once indicated by a curling of the terminal foliage in a way similar

* This is a brief review of Popular Bulletin No. 451 of this Station on Leaf-Hoppers Injurious to Apple Trees, by F. H. Lathrop. Anyone specially interested in the detailed account of the investigations will be furnished, on application, with a copy of the complete bulletin. Names of those who so request will be listed to receive future bulletins of the Station, popular or complete edition as desired. For Bulletin see p. 285.

to that caused by an attack of green apple aphis (see frontispiece). Continuous attacks year after year result in a bushy, much branched tree. This malformed growth is frequently killed during the winter, thereby increasing the amount of damage. This species attacks various cultivated plants and weeds, as well as apple and nursery stock.

The unicolored leaf-hopper. This species (*Empoasca unicolor*) very closely resembles the apple leaf-hopper in both the nymphal and adult stages. In fact, the two can scarcely be distinguished without the use of a microscope. For practical purposes, however, the grower can separate them by the differences in habits and injury. The unicolored leaf-hopper, altho it seems to prefer the younger trees, attacks the older leaves. Unlike the apple leaf-hopper, this species causes no curling, but, instead, produces a characteristic white stippling of the upper surfaces of the leaves. At the beginning of the attack these spots appear as isolated white points, but as the severity of the attack increases the spots merge and the entire leaf becomes pallid and functionless.

The rose leaf-hopper. Being of a white or very pale yellow color in both the nymphal and the adult stages, this species (*Empoa rosæ*) is rather easy to distinguish from the other two species. Like the unicolored leaf-hopper, the rose leaf-hopper confines its attacks largely to the older leaves of the tree, where the injury also takes the form of a severe white stippling. However, it was noticed that the rose leaf-hopper is more prevalent on older trees, while the unicolored leaf-hopper prefers nursery or young orchard trees. Both of these leaf-hoppers have a habit of constantly discharging droplets of liquid, which fall upon the fruit and leaves, forming tiny round spots of a dark greenish or black color. In severe cases this may materially spoil the appearance of the fruit if it is not removed by rain.

Life histories. In a general way the life histories of these three species are similar. Eggs are deposited either in the bark or in the leaves of the infested plants. The eggs hatch to produce tiny wingless creatures or nymphs. These nymphs feed on the undersides of the leaves, running rapidly when disturbed, and generally keeping out of sight. As the nymph grows older it increases in size, and wing pads are developed. Finally, the nymph matures, and the winged adult appears.

The activities of the several species differ, however, in important details. The rose leaf-hopper spends the winter in the egg stage, and by far the larger number of the winter eggs are deposited in the bark of the rose. These eggs hatch in late May, and the nymphs which appear mature during late June. The adults migrate to apple, where they produce the summer generation. In the fall the

return migration takes place, and the winter eggs are deposited in the bark of the rose.

The apple leaf-hopper was found to spend the winter in the adult stage. The nymphs appear on apple during late June. This species breeds thruout the summer on apple as well as on many other trees and plants, producing two or possibly three generations before activities cease in the fall.

The unicolored leaf-hopper spends the winter in the egg stage on apple. Nymphs appear in late May and mature in early July. The species is single brooded, and no eggs are deposited until fall.

Control. For the protection of foliage, especially of nursery stock or of newly planted apple orchards, chief reliance should be placed on soap and nicotine mixtures of standard strengths. In spraying, the application should be made when the maximum number of nymphs in the younger stages are present, for the adults escape the spray by flying, and are probably resistant to the solution even when they are reached. In case of the apple leaf-hopper it is important to spray before the foliage has been curled, and for this reason it is well to examine nursery and young orchard trees from time to time during the season to determine whether or not nymphs are sufficiently numerous to require treatment. Coarse nozzles and fairly high pressure should be used, applying sufficient material to wet thoroly the undersides of the leaves and, generally speaking, the most satisfactory results can be obtained only by drenching the insects. With nursery stock and young trees, immersion of the growing tips into a receptacle containing a quantity of the spraying material is an effective method of treatment.

In a series of spraying tests in which soap, nicotine and kerosene emulsion were also compared, a high degree of effectiveness was indicated for a spraying mixture composed of nicotine sulphate 1 pint, lump lime 60 pounds, copper sulphate 4 pounds, and water 100 gallons. The copper sulphate was dissolved in four gallons of water, and then the lime was slaked to form a thin paste. These were then mixed together and diluted with water to make the required amount, after which the nicotine sulphate was added. After straining the lime thru a fine metal sieve directly into the tank, during which operation the agitator was kept in action to secure an even distribution of the materials, the suction intake was placed in the tank, when spraying was immediately undertaken. This formula or some modification of it, as may be suggested by future experience, will probably be found to have as its chief field of usefulness the treatment of young non-bearing orchards where it is desired to combat the green aphis as well as leaf-hoppers.

For bearing orchards it is probably not advisable to make a special application to control these pests. In orchards which receive the

routine insecticidal sprays these leaf-hoppers are usually sufficiently controlled during normal seasons to prevent any appreciable reduction of the crop.

One phase of this problem should, however, not be overlooked, and that is the activities of the leaf-hoppers in transmitting fire-blight. Proof of a vital relationship between these agents and the demonstration that the different leaf-hoppers are an essential or an important element in the spread of the disease during midsummer would certainly prove additional incentives for growers to adopt some system of spraying, aiming either at the individual or collective control of these pests.

Mention has been made of the fact that the apple leaf-hopper breeds on a large number of plants, including various weeds. To remove vegetation that harbors the insects, orchards should be cultivated or mowed to prevent the growth of weeds. Attention is also called again to the fact that the rose leaf-hopper breeds abundantly on currants and gooseberries, which should be considered in any plans that provide for the interplanting of apples with these bush fruits.

PERIODICALS RECEIVED BY THE STATION.

Abstracts of Bacteriology	Subscription
Agricultural Digest	Complimentary
Agricultural Gazette of Canada	Complimentary
Agricultural Gazette of New South Wales	Complimentary
Agricultural Journal of India	Complimentary
Agricultural Review	Subscription
American Agriculturist	Subscription
American Chemical Society Journal	Subscription
American Entomological Society (Transactions)	Subscription
American Fertilizer	Subscription
American Florist	Subscription
American Food Journal	Complimentary
American Fruit Grower	Complimentary
American Grocer	Complimentary
American Hay, Flour and Feed Journal	Complimentary
American Journal of Botany	Subscription
American Journal of Physiology	Subscription
American Miller	Complimentary
American Museum of Natural History, Bulletin	Complimentary
American Naturalist	Subscription
American Philosophical Society, Proceedings	Complimentary
American Poultry Advocate	Complimentary
American Society of Agronomy, Journal	Subscription
American Thresherman & Farm Power	Complimentary
Analyst	Subscription
Annales de L'Institut Pasteur	Subscription
Annals and Magazine of Natural History	Subscription
Annals of Applied Biology	Subscription
Annals of Botany	Subscription
Annals of the Missouri Botanical Garden	Subscription
Better Fruit	Complimentary
Biological Bulletin	Subscription
Boletim de Agricultura	Complimentary
Boletin de la Sociedad Entomologica de Espana	Complimentary
Boletin do la Sociedad Nacional de Agricultura	Complimentary
Botanical Abstracts	Subscription
Botanical Gazette	Subscription
Caledonia Era	Complimentary
California Academy of Sciences, Proceedings	Complimentary
California Cultivator	Complimentary

California Fruit News	Subscription
California University Publications — Agricultural Sciences, Botany and Zoology	Complimentary
Canadian Entomologist	Subscription
Canadian Horticulturist	Complimentary
Chemical Abstracts	Subscription
Chemical Society, Journal	Subscription
Chicago Dairy Produce	Complimentary
Cold	Complimentary
Commercial Fertilizer	Complimentary
Country Gentleman	Subscription
Country Life	Subscription
Creamery and Milk Plant Monthly	Complimentary
Curtis' Botanical Magazine	Subscription
Dairy and Produce Review	Complimentary
Duroc Bulletin	Complimentary
Entomological News	Subscription
Entomological Society of America, Annals	Subscription
Entomological Society of Washington, Proceedings	Subscription
Entomologist	Subscription
Entomologist's Record	Subscription
Farm and Dairy and Rural Home	Complimentary
Farm and Fireside	Complimentary
Farm Engineering	Complimentary
Farm, Stock and Home	Complimentary
Farmers' Advocate	Complimentary
Farmers' Review	Complimentary
Feathered World	Subscription
Field, The, Illustrated	Complimentary
Florists' Exchange	Subscription
Flour and Feed	Complimentary
Fruit Grower	Complimentary
Garden	Subscription
Gardeners' Chronicle	Subscription
Gleanings in Bee Culture	Complimentary
Grape Belt, The	Complimentary
Green's Fruit Grower	Complimentary
Guide to Nature	Subscription
Hawaiian Forester and Agriculturist	Complimentary
Hoard's Dairyman	Complimentary
Hospodar	Complimentary
Insect World (Japanese)	Complimentary
International Garden Club, Journal	Subscription
Journal of Agricultural Research	Complimentary
Journal of Agricultural Science	Subscription
Journal of Agriculture, Victoria	Complimentary

Journal of American Medical Association	Subscription
Journal of the American Peat Society	Subscription
Journal of Association of Official Agricultural Chemists	Subscription
Journal of Bacteriology	Subscription
Journal of Biological Chemistry	Subscription
Journal of Board of Agriculture (English)	Complimentary
Journal of the College of Agriculture, Tokyo	Complimentary
Journal of Dairy Science	Subscription
Journal of the Department of Agriculture of South Australia	Complimentary
Journal of the Department of Agriculture of Victoria	Complimentary
Journal of the New Zealand Department of Agriculture	Complimentary
Journal of Economic Biology	Subscription
Journal of Experimental Medicine	Subscription
Journal of Experimental Zoology	Subscription
Journal of Genetics	Subscription
Journal of Heredity	Subscription
Journal of Home Economics	Subscription
Journal of Hygiene	Subscription
Journal of Industrial and Engineering Chemistry	Subscription
Journal of Pathology and Bacteriology	Subscription
Journal of Physical Chemistry	Subscription
Journal of Physiology	Subscription
The Leghorn World	Complimentary
Market Growers' Journal	Complimentary
Memoirs of the Department of Agriculture in India	Complimentary
Monthly Bulletin, International Institute of Agriculture	Complimentary
Monthly Bulletin of the N. Y. State Department of Health	Complimentary
Monthly Weather Review	Complimentary
Mycologia	Subscription
National Farmer	Complimentary
National Farmer and Stockgrower	Complimentary
National Nurseryman	Complimentary
New York Academy of Science, Annals and Transactions	Subscription
New York Botanical Garden, Bulletin	Complimentary
New York Entomological Society, Journal	Subscription
New York Fruit & Produce News	Complimentary
Nut Grower	Complimentary
Ohio Journal of Science	Subscription
Pacific Poultry Breeder & Fanciers' Monthly	Subscription
Parasitology	Subscription
Photo-Miniature	Subscription
Physiological Researches	Subscription
Phytopathology	Subscription
Poultry Herald	Subscription
Poultry Item	Complimentary
Power	Subscription

Psyche	Subscription
Quarterly Journal	Complimentary
Recreation	Subscription
Reclamation Record	Complimentary
Reliable Poultry Journal	Subscription
Review of Applied Entomology	Subscription
Revue de Viticulture (For Vineyard Laboratory, Fredonia, N. Y.)	Subscription
Revue Generale de Botanique	Subscription
Revue Horticole	Subscription
Royal Agricultural Society Journal	Subscription
Rural Life	Complimentary
Rural New York	Subscription
Science	Subscription
Scientific American	Subscription
Seed World	Complimentary
Societe Entomologique de France, Bulletin	Complimentary
Societe Mycologique	Subscription
Soil Science	Subscription
Southern Planter	Complimentary
Stazione Sperimentale Agrarie Italiane	Complimentary
Tijdschrift over Plantenzirkten	Complimentary
Torrey Botanical Club, Bulletins and Memoirs	Subscription
Utica Semi-Weekly Press	Complimentary
Vertical Farming	Complimentary
Wallace's Farmer	Complimentary
Wilson Bulletin	Complimentary

METEOROLOGICAL RECORDS FOR 1918.

METEOROLOGICAL RECORDS FOR 1918.

Reading of the Standard Air Thermometer.

DATE.	January.			February.			March.			April.			May.			June.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	—2.	10.	4.	3.	2.	3.	27.	30.	30.	50.	72.	57.	42.	41.	51.	80.	85.	89.
2	—9.	16.	5.	—1.	18.	19.	27.	39.	47.	54.	63.	63.	49.	64.	64.	74.	81.	76.
3	—2.	2.	—1.	19.	18.	28.	26.	27.	26.	32.	33.	34.	44.	57.	55.	66.	75.	74.
4	6.	13.	9.	0.	3.	—4.	20.	36.	34.	31.	41.	40.	45.	54.	56.	53.	57.	62.
5	10.	20.	19.	—10.	—6.	—6.	36.	40.	40.	31.	42.	42.	50.	69.	78.	58.	71.	72.
6	7.	23.	20.	15.	21.	29.	31.	27.	25.	36.	50.	55.	70.	81.	77.	57.	68.	67.
7	31.	32.	32.	18.	17.	21.	19.	23.	23.	48.	59.	48.	66.	74.	72.	58.	66.	64.
8	20.	19.	16.	—3.	18.	14.	32.	40.	40.	44.	46.	42.	54.	50.	57.	53.	66.	67.
9	20.	21.	20.	30.	35.	25.	28.	32.	26.	24.	24.	28.	49.	67.	73.	61.	60.	65.
10	23.	24.	27.	23.	29.	29.	13.	16.	16.	25.	37.	39.	68.	68.	62.	52.	67.	67.
11	24.	28.	24.	28.	43.	43.	9.	27.	36.	32.	33.	39.	40.	53.	53.	59.	69.	75.
12	37.	22.	11.	40.	39.	44.	39.	54.	52.	32.	37.	36.	55.	63.	72.	67.	63.	58.
13	0.	8.	9.	31.	34.	36.	31.	43.	42.	37.	50.	50.	64.	65.	54.	54.	62.	67.
14	11.	21.	19.	30.	37.	40.	36.	39.	42.	41.	63.	63.	50.	66.	65.	58.	66.	67.
15	20.	20.	20.	45.	35.	19.	26.	20.	18.	48.	68.	69.	50.	59.	64.	57.	65.	70.
16	8.	16.	17.	8.	16.	18.	22.	37.	42.	45.	66.	62.	57.	77.	76.	62.	77.	76.
17	21.	28.	23.	9.	18.	17.	40.	57.	48.	52.	65.	55.	67.	81.	79.	66.	71.	70.
18	17.	26.	19.	2.	22.	29.	33.	45.	44.	32.	57.	35.	68.	78.	80.	63.	73.	72.
19	1.	11.	7.	33.	43.	43.	48.	61.	58.	29.	40.	39.	65.	81.	70.	57.	67.	76.
20	5.	14.	11.	30.	19.	11.	38.	68.	68.	33.	51.	42.	65.	82.	66.	57.	64.	67.
21	10.	19.	11.	—1.	5.	4.	39.	65.	69.	44.	48.	57.	54.	69.	71.	56.	64.	65.
22	13.	22.	18.	4.	16.	20.	46.	58.	47.	41.	48.	53.	62.	75.	68.	55.	54.	47.
23	15.	16.	12.	17.	38.	41.	26.	32.	35.	48.	50.	45.	62.	65.	64.	41.	50.	59.
24	9.	15.	20.	35.	46.	49.	24.	38.	42.	31.	36.	37.	54.	66.	69.	59.	69.	75.
25	23.	30.	29.	32.	48.	48.	35.	44.	39.	35.	48.	50.	61.	65.	72.	59.	73.	76.
26	9.	12.	9.	21.	22.	23.	25.	26.	27.	41.	56.	61.	55.	58.	69.	63.	70.	77.
27	—1.	7.	1.	24.	44.	44.	25.	30.	29.	50.	66.	68.	74.	81.	81.	61.	77.	78.
28	—2.	13.	24.	34.	33.	32.	29.	39.	40.	49.	68.	69.	68.	71.	68.	64.	71.	75.
29	17.	20.	18.	....	....	....	32.	50.	54.	59.	66.	66.	63.	65.	66.	69.	83.	77.
30	6.	16.	15.	....	....	....	43.	57.	54.	50.	60.	57.	60.	68.	73.	70.	80.	79.
31	12.	20.	17.	....	....	....	44.	62.	71.	....	....	....	70.	81.	82.	....	....	....
Averages	11.5	18.1	15.6	18.4	25.3	25.6	30.6	40.7	40.7	40.1	51.4	50.0	58.0	67.5	67.9	60.3	68.8	69.9

READING OF THE STANDARD AIR THERMOMETER (*concluded*).

DATE.	July.			August.			September.			October.			November.			December.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	63.	67.	64.	59.	74.	79.	58.	71.	75.	36.	55.	54.	41.	43.	40.	19.	24.	19.
2	50.	67.	73.	65.	79.	74.	62.	80.	77.	49.	69.	67.	38.	43.	40.	25.	33.	34.
3	56.	71.	64.	60.	68.	65.	64.	66.	70.	53.	58.	56.	38.	50.	46.	31.	32.	35.
4	58.	75.	77.	63.	68.	75.	62.	72.	73.	40.	60.	58.	41.	45.	42.	33.	30.	29.
5	58.	70.	76.	74.	89.	93.	71.	73.	58.	55.	68.	72.	38.	48.	44.	24.	25.	25.
6	75.	80.	78.	73.	89.	93.	54.	61.	63.	56.	61.	47.	27.	48.	47.	24.	21.	15.
7	57.	68.	66.	83.	95.	94.	51.	68.	67.	42.	49.	50.	38.	55.	57.	18.	32.	34.
8	56.	61.	62.	72.	84.	91.	54.	64.	70.	34.	59.	63.	47.	51.	54.	38.	42.	44.
9	55.	58.	62.	71.	70.	76.	55.	70.	77.	45.	66.	64.	54.	54.	53.	34.	40.	31.
10	60.	67.	64.	68.	77.	72.	59.	52.	58.	44.	66.	68.	40.	45.	39.	15.	25.	22.
11	63.	74.	71.	73.	86.	87.	42.	60.	66.	55.	74.	73.	30.	40.	36.	31.	34.	36.
12	65.	75.	76.	70.	86.	90.	60.	66.	70.	55.	60.	67.	24.	41.	42.	32.	40.	33.
13	68.	78.	79.	74.	94.	98.	54.	60.	65.	62.	64.	55.	36.	48.	45.	34.	35.	40.
14	68.	81.	84.	79.	83.	85.	54.	68.	70.	45.	45.	47.	36.	35.	40.	46.	54.	51.
15	70.	84.	88.	65.	76.	80.	56.	73.	73.	37.	50.	51.	34.	58.	54.	37.	40.	39.
16	66.	85.	82.	66.	76.	76.	60.	56.	55.	42.	59.	59.	44.	51.	47.	35.	38.	36.
17	64.	69.	76.	62.	72.	71.	50.	55.	58.	42.	57.	63.	50.	56.	55.	25.	36.	34.
18	69.	79.	78.	55.	71.	69.	43.	48.	60.	40.	44.	44.	52.	60.	48.	29.	33.	32.
19	65.	78.	83.	51.	74.	76.	53.	59.	50.	30.	49.	55.	45.	48.	43.	27.	49.	41.
20	68.	87.	85.	59.	81.	79.	47.	52.	52.	48.	50.	54.	40.	39.	36.	34.	46.	43.
21	73.	90.	94.	60.	80.	87.	47.	52.	53.	42.	49.	47.	35.	35.	37.	34.	45.	48.
22	75.	94.	88.	72.	84.	87.	44.	56.	53.	33.	52.	52.	34.	33.	30.	46.	50.	50.
23	71.	83.	79.	73.	92.	91.	50.	63.	56.	39.	53.	60.	30.	36.	32.	42.	45.	39.
24	73.	87.	70.	72.	85.	75.	50.	60.	56.	40.	57.	58.	32.	43.	37.	31.	35.	37.
25	70.	78.	82.	68.	84.	83.	46.	55.	54.	55.	58.	56.	33.	35.	33.	39.	39.	34.
26	73.	88.	87.	66.	83.	78.	51.	47.	51.	57.	64.	64.	20.	27.	25.	25.	22.	19.
27	75.	91.	93.	62.	76.	77.	46.	55.	55.	56.	73.	65.	35.	40.	34.	21.	29.	25.
28	75.	85.	79.	65.	73.	75.	54.	67.	68.	60.	68.	66.	29.	40.	43.	21.	21.	21.
29	78.	87.	81.	66.	79.	76.	47.	54.	54.	49.	63.	60.	42.	41.	40.	23.	31.	28.
30	62.	67.	68.	59.	74.	74.	45.	50.	46.	53.	55.	54.	33.	35.	30.	27.	32.	30.
31	59.	73.	69.	65.	71.	68.	....	....	....	47.	50.	45.	....	....	....	30.	35.	38.
Averages	65.7	77.3	76.7	60.6	79.7	80.4	52.9	61.1	61.7	46.4	58.2	64.7	37.2	44.2	41.6	30.0	35.2	33.6

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1918.

DATE.	January.		February.		March.		April.		May.		June.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	16.	—6.	17.	1.	32.	26.	73.	34.	57.	39.	90.	67.
2	18.	—10.	23.	—10.	49.	20.	65.	48.	68.	38.	90.	68.
3	6.	—2.	32.	4.	47.	25.	63.	29.	64.	40.	76.	59.
4	14.	—1.	28.	—4.	47.	17.	45.	26.	58.	42.	74.	49.
5	23.	9.	—4.	—11.	40.	32.	46.	26.	78.	35.	75.	50.
6	27.	6.	29.	—6.	43.	25.	56.	28.	84.	58.	72.	53.
7	33.	16.	38.	16.	29.	17.	60.	40.	77.	57.	70.	57.
8	32.	16.	21.	—7.	43.	14.	51.	42.	72.	47.	71.	44.
9	23.	15.	38.	12.	40.	25.	42.	23.	74.	39.	70.	48.
10	27.	17.	30.	20.	44.	13.	40.	24.	73.	58.	69.	51.
11	29.	23.	49.	26.	36.	7.	39.	29.	62.	38.	76.	40.
12	40.	11.	48.	37.	54.	29.	39.	30.	73.	47.	75.	56
13	16.	—3.	50.	30.	52.	31.	52.	31.	72.	52.	64.	48.
14	25.	9.	44.	25.	43.	33.	66.	34.	67.	43.	70.	51
15	23.	16.	45.	19.	53.	17.	70.	36.	65.	40.	72.	49.
16	23.	6.	19.	8.	44.	14.	69.	36.	78.	46.	80.	49.
17	31.	12.	20.	7.	58.	36.	67.	44.	81.	53.	76.	61.
18	26.	16.	29.	2.	50.	29.	57.	31.	84.	54.	75.	48.
19	19.	—3.	44.	24.	69.	34.	41.	26.	83.	59.	79.	47.
20	15.	—5.	55.	11.	74.	37.	52.	27.	83.	61.	68.	38.
21	20.	8.	11.	—1.	73.	37.	61.	38.	74.	52.	69.	47.
22	22.	2.	21.	1.	69.	40.	58.	37.	82.	52.	56.	47.
23	18.	12.	43.	7.	47.	25.	55.	43.	68.	60.	60.	39.
24	20.	8.	50.	30.	51.	20.	45.	29.	70.	40.	76.	49.
25	30.	20.	51.	32.	46.	29.	53.	29.	72.	57.	77.	52.
26	30.	8.	49.	21.	39.	26.	62.	26.	72.	50.	79.	55.
27	10.	—3.	47.	16.	31.	24.	69.	41.	83.	65.	80.	54.
28	24.	—8.	44.	32.	44.	21.	72.	40.	81.	62.	79.	55.
29	26.	15.	......	......	56.	23.	73.	52.	69.	59.	84.	62.
30	20.	5.	......	......	59.	30.	68.	43.	73.	55.	84.	61.
31	22.	—1.	......	......	71.	40.	......	......	84.	59.	......	......
Averages	22.8	6.7	34.7	12.2	49.5	25.7	57.0	34.1	73.6	50.2	74.6	51.8

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1918 (*concluded*).

DATE.	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	79.	59.	79.	46.	77.	53.	59.	30.	49.	35.	35.	18.
2	73.	49.	82.	52.	82.	51.	72.	42.	46.	35.	35.	18.
3	73.	48.	74.	49.	77.	62.	68.	49.	52.	36.	37.	30.
4	78.	49.	75.	54.	76.	58.	62.	34.	47.	40.	37.	30.
5	78.	58.	94.	67.	73.	57.	74.	45.	51.	37.	30.	21.
6	81.	54.	96.	68.	65.	53.	72.	48.	55.	27.	29.	25.
7	79.	50.	97.	73.	70.	48.	53.	37.	62.	35.	36.	9.
8	67.	51.	94.	71.	71.	49.	67.	30.	60.	45.	50.	29.
9	62.	52.	91.	68.	77.	46.	69.	34.	57.	50.	45.	31.
10	70.	58.	78.	60.	77.	52.	73.	40.	55.	38.	35.	14.
11	74.	55.	90.	66.	66.	31.	76.	53.	45.	27.	38.	20.
12	77.	52.	92.	68.	70.	56.	75.	51.	50.	23.	41.	32.
13	80.	55.	98.	65.	70.	53.	69.	53.	55.	33.	40.	29.
14	85.	58.	98.	70.	71.	48.	55.	41.	46.	35.	55.	40.
15	89.	56.	86.	59.	76.	49.	52.	31.	65.	33.	50.	36.
16	88.	59.	80.	57.	73.	55.	63.	41.	56.	43.	40.	32.
17	83.	62.	76.	51.	60.	48.	65.	38.	60.	47.	40.	33.
18	81.	58.	75.	45.	62.	38.	63.	40.	62.	50.	39.	24.
19	83.	60.	79.	45.	60.	47.	57.	29.	51.	42.	50.	24.
20	88.	53.	84.	48.	53.	44.	57.	44.	46.	36.	50.	32.
21	95.	61.	89.	54.	57.	42.	54.	39.	40.	35.	50.	34.
22	95.	66.	90.	61.	58.	38.	58.	31.	41.	32.	54.	42.
23	89.	67.	95.	66.	64.	47.	61.	33.	37.	29.	52.	39.
24	93.	67.	91.	66.	62.	49.	62.	37.	47.	29.	40.	31.
25	82.	66.	88.	57.	57.	39.	62.	53.	41.	30.	42.	35.
26	91.	67.	86.	58.	61.	43.	66.	55.	34.	20.	34.	26.
27	94.	70.	80.	53.	60.	38.	76.	55.	44.	21.	30.	19.
28	95.	68.	80.	56.	73.	48.	71.	57.	45.	27.	27.	21.
29	88.	68.	80.	62.	68.	43.	78.	46.	48.	39.	34.	20.
30	81.	61.	78.	52.	54.	40.	62.	52.	42.	30.	34.	25.
31	75.	53.	76.	62.	......	......	57.	46.	......	......	39.	22.
Averages	82.1	58.4	85.6	59.	67.3	47.5	64.7	42.3	44.6	34.6	40.	27.1

SUMMARY OF AVERAGES OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS FOR 1918.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum	22.8	34.7	49.5	57.	73.6	74.6	82.1	85.6	67.3	64.7	44.6	40.
Minimum	6.7	12.2	25.7	34.1	50.2	51.8	58.4	59.	47.5	42.3	34.6	27.1
Standard 7 A. M.	11.5	18.4	30.6	40.1	58.	69.3	65.7	60.6	52.9	46.4	37.2	30.
Standard 12 M.	18.1	25.3	40.7	51.4	67.5	68.8	77.3	79.7	61.1	58.2	44.2	35.2
Standard 5 P. M.	15.6	25.6	40.7	50.	67.9	69.9	76.7	80.4	61.7	57.8	41.6	40.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1918 INCLUSIVE.

(Highest and Lowest Record for Each Month in Heavy Type.)

	January.				February.				March.				April.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	18	44.	11	—9.	17	48.	24	—2.	19	61.	9	2.	16	75.	1	19.
1884	14	42.	26	—13.	7	55.	29	—3.	30	54.	1	—4.	28	74.	1	23.
1885	1	61.	29	—6.	10	38.	11	—11.5	28	48.	13	—11.	24	84.5	10	20.5
1886	5	52.5	13	—18.7	9	50.	27	—11.	16	58.	2	—2.5	24	80.5	4	22.
1887	24	50.7	19	—8.	9	54.2	27	—4.	3	51.7	1 & 5	8.7	11	75.7	1	17.2
1888	2	43.2	23	—6.	21	49.	10	—7.	28	57.	13	0.	29	82.5	8	19.
1889	18	55.	20	5.	23	42.	4 & 24	—7.	28	61.8	30	18.5	20	84.	1	26.
1890	6	67.	29	9.	5	64.5	11&21	9.5	13	62.	8	2.	13	78.8	1& 19	23.
1891	3	46.	17	4.	26	56.8	15	2.5	12	57.	2	4.5	28	81.4	7	21.
1892	3	48.	10	—5.	15	44.	6	2.8	27	52.2	4	6.	6	78.	17	25.5
1893	29	46.	11	—6.	15	47.4	5	—1.	24	54.	5	9.	13	75.3	26.2	25.
1894	5	59.	13	11.	20	47.6	27	—8.5	18	73.	26	15.	21	71.3	2	20.
1895*	7	45.	19	4.	25	46.	8	—14.	25	52.	5 & 16	12.	30	80.	3	28.
1896	30	44.	6	—16.5	29	49.	17	—21.	31	56.5	24	—2.	17	87.	4& 5	19.
1897	5	58.	20	—3.5	18	49.5	1 & 27	5.5	21	64.	1	—1.	26	82.	20	19.
1898	13	57.	30&31	—4.	12	56.5	2 & 3	—2.	11	†65.	2	17.5	14&18	69.	69	18.
1899	5	59.	12	—4.	21	52.5	11	—8.	73	63.	21	13.	30	82.	3	23.
1900	23	56.	1	2.	14	57.	27	0.	10	46.	12	—3.	30	‡73.5	9	22.
1901	16	48.	20	—2.	16	36.	24	—2.5	24	67.	6	—1.	28	78.	12	28.
1902	3	44.	28	2.	28	52.	6	—3.	12	66.5	19	14.	22	87.	5	25.
1903	3	48.	9	—2.	28	62.5	18	—4.	19	78.5	1 & 2	19.	30	86.	5	21.
1904	23	48.	19	—14.	7	58.	16	18.	26	58.	4	8.	24	67.5	14	16.
1905	1	49.	26	—2.	20	45.	5 & 14	—6.	29	82.	5	1.	27&28	75.	16	23.
1906	21	71.	9	4.	24	64.	6 & 7	—7.	27	51.	25	2.	19	74.	2	25.
1907	6	53.	24	—18.	2	47.	12	—4.	29	83.	7	—1.	29	73.	2	19.
1908	22	45.	31	—9.	15	53.	2 & 5	—14.	28	73.	1	8.	27	78.	4	18.
1909	24	64.	19	—7.	5	52.	1	—1.	10	52.	5	5.	19	75.	11	12.
1910	2 & 22	45.	5	—8.	16	29.	7	—3.	24	82.	14&18	17.	4	84.	7	27.
1911	27&30	48.	5	—1.	17	52.	22	4.	27	60.	16	—1.	29	80.	3	18.
1912	18	44.	14	—12.	24	48.	10	—10.	31	62.	4	—1.	6	78.	4	19.
1913	17	57.	13	8.	20	65.	10	—10.	14&15	69.	7 & 8	1.	24	84.	20	24.
1914	29	51.	13&14	—9.	3	52.	13&24	—14.	26	65.	12	7.	19	82.	9 & 13	22.
1915	7	46.	30	—3.	21&23	53.	10	10.	25	50.	1	11.	25&26	88.	5	23.
1916	27	61.	17	—3.	1	47.	15	—8.	31	58.	18	—3.	21	73.	8	26.
1917	6	47.	11&12	1.	26	55.	13	—8.	31	68.	6 & 29	11.	22	80.	11&18	23.
1918	12	40.	2	—10.	20	55.	5	—11.	20	74.	11	7.	1& 29	73.	9	23.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Maximum for first eleven days only. Record incomplete.
‡ Thermometers broken. Record not taken from April 19th to 24th inclusive.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1918 INCLUSIVE (*continued*).
(Highest and Lowest Record for Each Month in Heavy Type.)

	May.				June.				July.				August.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	11	87.	1 & 14	31.	7	86.5	2	42.	5	89.	1	46.	23	92.	15	46.
1884	24	88.	30	32.	25	90.	15	41.	2	87.5	15	50.	20	95.	25	44.
1885	18	81.7	3	27.5	14	86.5	23	41.5	18	90.5	12	46.5	1	89.	28	45.
1886	23	79.5	17&18	37.2	14	86.2	1	42.2	7	95.	1	45.2	30	91.5	6	47.7
1887	23	88.2	14	37.5	17	89.2	15	47.7	3	95.5	11	58.7	3	88.5	8	46.
1888	13	79.8	3	29.	23	94.1	4	40.	5	89.8	16	47.	9	92.6	23	48.3
1889	18	91.8	29	32.	22	85.	5	46.	11	90.7	6	50.5	31	86.7	16&17	50.3
1890	4	80.7	2	30.	30	85.6	8	44.8	9	94.5	24	46.5	4	96.2	24	46.0
1891	11	85.5	4	29.5	16	95.	6	40.	14	92.	31	46.	12	92.	29	46.5
1892	31	78.	9	34.2	14	92.	11	45.8	29	96.3	2	46.4	10	95.5	28	49.
1893	25	88.	9	35.	21	94.	1	44.	26	95.5	24	48.4	11	94.5	13	49.
1894	2	85.4	14	32.6	23	91.6	6	39.	21	97.	10	49.6	25	93.	27	45.3
1895*	31	92.	13&21	36.	3	96.	7	54.	8	94.	11	52.	11	88.	22	44.
1896	11	87.5	7 & 20	40.	21	89.	3	41.	3	94.	18	49.	6 & 7	96.	29	44.
1897	24	80.	8	32.5	24&25	87.5	2	42.	11	97.	15	57.	15	87.5	21	46.
1898	29	79.	6	34.	9	90.	16	40.	4	96.5	12	40.	24	90.5	28	47.
1899	2	87.5	15	32.5	6 & 24	93.	11	41.5	4	97.5	1	50.	20	97.5	15	44.5
1900	15&16	88.5	7	27.	25	93.	10	45.	17	96.	1	50.	11	97.	2	51.
1901	23	78.	16	36.	27, 28 & 29	95.5	2	42.	1	97.5	20	54.5	22	90.	5	52.
1902	22	90.	11	26.	3	85.	6	38.	14&27	90.	1	53.	31	90.	13	47.
1903	19	89.	2	24.	30	86.5	1	39.	9	94.	15	50.	18	85.5	8 & 14	45.
1904	25	88.	12	31.5	5–24 & 25	89.	12&17	45.	19	93.	3	49.	25	89.5	19	45.
1905	3	82.	2	29.5	19	90.	1	40.	18	92.	22	48.5	10	93.	27	41.
1906	24	88.5	11&21	30.	8	92.	12	37.	20–22 & 23	89.	25	50.	5	93.	16	47.
1907	14	85.	2–11 & 12	28.	18	94.	3	41.	16	90.	4	46.	12	96.5	19	41.5
1908	29	90.	1–4&5	31.	19	92.	12	43.	6–11 & 30	94.	9	52.	4	95.	25	46.
1909	31	78.	2 & 3	33.	28	90.	8	43.	15	92.	4	42.	8	98.	31	42.
1910	20	79.	16	31.5	22	89.9	4	36.	9	96.5	5	50.	3 & 15	90.	27	44.
1911	22	97.	3	27.	11	90.5	17	46.	5	105.	25–26 & 27	50.	8	94.5	30	47.
1912	24	88.	14	34.	1	89.	8	40.	8 & 10	95.	1	41.	14	92.	17	44.
1913	4	91.	11	30.	30	92.	9	37.	1 & 4	95.	12	50.	17	98.	25&26	44.
1914	26&27	90.	1	34.	24&25	90.	20	39.	11	93.	4	50.	9	94.	26	47.
1915	23	77.	3 & 4 10&27	34.	18&19	86.	4 & 9	41.	31	90.	22&23	49.	1	89.	27	43.
1916	24&28	82.	10&19	37.	27	82.	1	41.	30	96.	1	49.	22	101.	2 & 29	46.
1917	19	82.	4	32.	13&19 & 20	83.	16&17	46.	31	96.	4	50.	1 & 2	96.	31	47.
1918	6–18 & 31	84.	5	35.	1 & 2	90.	20	38.	21–22 & 28	95.	3	48.	13&14	98.	18&19	45.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1918, INCLUSIVE (*concluded*).

(Highest and Lowest Record for Each Month in Heavy Type.)

	SEPTEMBER.				OCTOBER.				NOVEMBER.				DECEMBER.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	17	80.	11	37.	11	78.	17&18	25.	22	70.	17	13.	9 & 14	56.	23	—7.5
1884	5	94.	14	26.	5	84.2	27	23.	11	63.	25	15.	31	55.5	20	—15.5
1885	27	83.7	24	40.	1	79.	13	25.	8 & 13	68.	28	18.	24	53.	9	4.
1886	11	89.5	22	49.	10	76.7	17	27.5	3	68.2	28	17.	11&25	46.	6	—6.
1887	22	81.7	27	37.2	9	78.5	31	21.2	28	68.	30	15.	12	54.7	2	—3.
1888	1 & 10	83.	7	40.	6	62.7	22	29.	1 & 3	73.	23	8.	27	53.	22	4.
1889	4	84.	22 & 23&29	40.	2	68.7	24	21.2	4	61.7	17	17.8	25	60.5	4 & 5	8.
1890	8	83.6	25	35.5	5	69.8	31	32.	8	65.4	28	17.	1	46.2	20	3.
1891	26	92.8	30	43.	4	89.4	12&25	27.	1	68.	29	12.	5	57.7	18	7.
1892	26	88.	20	39.	1	82.	2	33.1	19	60.	24	18.	9	49.2	27	—3.7
1893	5	80.	26	37.4	13	76.	31	25.	3	62.	27	19.	26	62.	14	1.5
1894	4	90.	26	33.	1	76.5	15	33.	3	65.	29	12.	17	59.	29	—0.2
1895*	4	94.	15&30	42.	2	72.	30	28.	7	68.	21	19.	20&21	62.	13	—2.
1896	12	95.	23	36.	30	77.5	10&19	29.	19	70.	21	19.5	14	58.	28	2.
1897	11	98.	21	37.5	16	88.	10&18	30.	6	65.	24	16.5	12	61.5	24	2.
1898	4	94.	21	40.5	1	85.5	28	31.	5	63.	28	16.	31	54.	14	3.
1899	4	92.	15&30	30.	15	86.	3	26.	19	60.	14	25.	12	60.	31	—1.
1900	12	95.	19	37.	6 & 7	89.	20	28.	22	70.	17	19.	4	55.	10&14	4.
1901	6	89.	26	36.	10&11	74.	28	28.	1	65.	27	13.	14	62.	18	—1.
1902	1	90.	15	38.	19	74.	10 & 22&30	29.	14	73.	29	22.	2	52.	9	—5.
1903	14	90.	29	35.	1	73.	25&27	28.	4	70.	26&27	12.	3	46.	19	—4.
1904	3	88.	23	33.	10	81.	31	22.	3	65.	29	9.	23	53.	16	—2.
1905	30	88.5	26	36.	1	85.	26	20.5	12	61.	14	11.	29	52.5	15	1.
1906	18	91.5	25	38.	5	79.5	13&31	30.	19	62.	30	16.	6	52.	8	—1.
1907	20	90.	27	39.	†3	80.	31	24.	1	59.	12&16	22.	30	57.	22	13.5
1908	10	92.	30	37.	18	83.	21	27.	26	68.	5	18.	1	64.	23	3.
1909	14	93.	2 & 6	35.	9	82.5	29&30	27.	11	75.	24	21.	6	45.	30	1.
1910	6	87.	15&23	40.	6	81.	30	26.	1	59.	23	21.	29	41.	31	—2.5
1911	2	87.	14	35.	4	78.	3	33.	11	68.	13	18.	9	67.9	4& 30	13.
1912	6 & 10	95.	30	34.	6	83.	16	31.	6 & 7	69.	28	20.	6	65.	9 & 12	12.
1913	3	95.	15	28.	6	81.	31	29.	22	73.	27	22.	7	56.	28	6.
1914	22	92.	29	38.	10	84.	27	26.	1	69.	24	16.	2	64.	26&27	—6.
1915	14	93.	28	35.	13	75.	25	29.	1	68.	18	21.	25	45.	31	4.
1916	7	93.	30	39.	8	87.	27	29.	8	74.	25	16.	5	62.	30	4.
1917	1 & 2	82.	23	35.	2 & 18 19&30	64.	10	26.	11	58.	27	9.	24	44.	30	—18.
1918	2	82.	11	31.	29	78.	19	29.	15	65.	28	20.	14	55.	7	9.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Thermometer broken on the 27th, 28th, and 29th of October.

YEARLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1918 INCLUSIVE.

(Highest and Lowest Record for THE TIME in Heavy Type.)

	Maximum for Each Year.		Minimum for Each Year.	
	Date.	Temp.	Date.	Temp.
1883	Aug. 23	92.	Jan. 11	— 9.
1884	Aug. 20	95.	Dec. 20	—15.5
1885	July 18	90.5	Feb. 11	—11.5
1886	July 7	95.	Jan. 13	—18.7
1887	July 3	95.5	Jan. 19	— 8.
1888	June 23	94.1	Feb. 10	— 7.
1889	May 18	91.8	Feb. 4 and 24	— 7.
1890	Aug. 4	96.2	Mar. 8	2.
1891	June 16	95.	Feb. 15	2.5
1892	July 29	96.3	Jan. 10	— 5.
1893	July 26	95.5	Jan. 11	— 6.
1894	July 21	97.	Feb. 27	— 8.5
1895*	June 3	96.	Feb. 8	—14.
1896	Aug. 6 and 7	96.	Feb. 17	**—21.**
1897	Sept. 11	98.	Jan. 20	— 3.5
1898	July 4	96.5	Jan. 30 and 31	— 4.
1899	July 4 and Aug. 20	97.5	Feb. 11	— 8.
1900	Aug. 1	97.	Feb. 27	0.
1901	July 1	97.5	Feb. 24	2.5
1902	May 24, July 14 and 27, August 31 and Sept. 1	90.	Dec. 9	— 5.
1903	July 9	94.	Feb. 18 and Dec. 19	— 4.
1904	July 19	93.	Feb. 16	—18.
1905	Aug. 10	93.	Feb. 5 and 14	— 6.
1906	Aug. 5	93.	Feb. 6 and 7	— 7.
1907	Aug. 12	96.5	Jan. 24	—18.
1908	Aug. 4	95.	Jan. 2 and 5	—14.
1909	Aug. 8	98.	Jan. 19	— 7.
1910	July 9	96.5	Jan. 5	— 8.
1911	July 5	**105.**	Jan. 5	— 1.
1912	Sept. 6	95.	Jan. 14	—12.
1913	Aug. 17	98.	Feb. 10	—10.
1914	Aug. 9	94.	Feb. 13 and 24	—14.
1915	Sept. 14	93.	Jan. 30	— 3.
1916	Aug. 22	101.	Feb. 15	— 8.
1917	July 31, Aug. 1 & 2	96.	Dec. 30	—18.
1918	Aug. 13 & 14	98.	Feb. 5	—11.

* Data from record kept by Mr. Edgar Parker; Station record not available.

MONTHLY AND YEARLY MEANS OF TEMPERATURES SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly averages.
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5	44.0
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2	46.1
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8	43.3
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2	45.5
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6	45.9
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3	44.6
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2	47.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4	46.7
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5	47.7
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2	45.9
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5	45.3
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5	48.6
1895	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4	......
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1	48.0
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2	47.6
1898	26.2	26.8	......	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9	......
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0	47.7
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7	48.4
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7	47.9
1902	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	53.6	43.1	46.3	25.7	47.4
1903	25.7	28.1	42.2	45.9	60.4	63.2	70.8	65.5	64.4	52.5	36.2	23.3	48.2
1904	18.9	23.1	30.9	41.4	60.3	67.8	70.0	68.2	61.9	48.4	36.9	22.5	45.9
1905	19.8	18.9	33.1	44.8	57.5	66.4	71.8	68.7	63.7	52.4	37.6	32.0	47.2
1906	32.5	26.1	27.6	46.4	57.5	68.2	71.4	72.8	67.3	51.2	37.9	26.1	48.8
1907	24.9	19.5	38.1	40.2	51.3	64.0	71.2	68.4	64.4	47.9	38.7	31.8	46.7
1908	25.9	21.3	34.6	44.8	59.2	68.8	73.4	68.8	67.0	52.9	40.0	29.2	48.8
1909	27.7	28.6	31.0	44.3	57.9	67.2	69.6	70.0	63.5	47.7	44.5	25.7	48.1
1910	25.1	22.1	42.1	50.1	54.9	65.2	73.1	69.0	63.2	53.1	35.7	21.5	47.9
1911	24.9	26.6	30.9	44.8	64.9	67.5	74.4	70.9	62.8	50.7	36.6	35.1	49.4
1912	15.9	21.6	28.2	45.1	58.9	64.3	73.2	68.6	68.4	53.5	42.5	33.9	47.8
1913	32.7	18.8	36.9	48.3	56.9	66.8	72.1	70.0	61.3	54.0	44.5	33.6	49.7
1914	25.4	17.7	31.7	43.4	60.2	67.3	59.9	70.5	61.4	55.4	39.2	26.0	46.5
1915	26.5	29.6	31.0	52.3	52.6	64.6	69.6	67.8	65.6	52.6	41.1	28.5	48.5
1916	29.0	19.5	27.5	49.5	59.5	61.5	72.5	73.5	66.0	58.0	45.0	33.0	49.5
1917	24.6	20.2	33.8	45.8	49.5	63.9	71.8	70.5	60.1	45.9	35.3	19.5	45.0
1918	33.6	23.4	37.6	45.6	61.9	63.2	58.4	72.2	57.4	53.5	22.1	33.6	46.8
Monthly averages	24.1	22.7	31.1	44.8	56.7	66.0	70.5	69.1	62.4	50.7	38.6	28.4	44.2

PRECIPITATION BY RAINFALL ONLY BY MONTHS SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	......	......	......	......	......	3.69	2.42	2.37	1.25	0.62	1.22	0.55	......
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	2.88	0.99+	4.02	2.73	3.47	2.02	1.24	20.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	4.26	1.07	4.34	5.81	4.54	2.40	......	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	2.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	......	0.29	1.36	2.88	......	......	2.66	0.94	0.72	2.31	2.49	......
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	......	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.29	2.41	2.88	2.32	0.74	0.74	26.89
1903	1.81	1.11	5.62	2.60	0.23	7.77	4.86	7.21	1.30	4.19	1.63	0.38	38.69
1904	0.80	1.03	2.41	1.67	4.04	3.37	5.73	2.56	3.26	2.06	0.26	1.42	28.61
1905	0.40	0.27	1.09	2.05	2.01	8.78	3.59	5.44	1.90	3.69	1.32	1.84	32.38
1906	1.46	0.53	1.60	2.08	4.24	5.31	2.37	3.68	2.16	3.56	1.40	1.54	29.93
1907	1.89	0.03	1.14	2.42	1.82	2.34	2.86	1.35	2.73	2.48	2.78	1.89	24.73
1908	0.68	1.12	1.24	3.28	3.57	1.96	4.72	1.79	1.66	2.73	0.88	0.43	24.06
1909	0.94	1.68	1.35	3.20	2.83	2.17	2.04	2.21	2.22	1.18	0.56	0.49	20.87
1910	0.87	0.53	0.28	4.56	3.45	1.55	2.39	5.47	3.29	1.73	0.62	0.38	25.12
1911	0.91	0.24	1.07	3.24	1.36	2.51	4.49	3.36	3.21	2.37	1.41	2.08	26.25
1912	0.20	0.95	1.92	3.41	7.27	2.09	4.85	2.21	5.89	1.42	1.48	1.13	32.82
1913	3.88	0.11	4.64	3.40	2.68	3.24	2.03	1.65	2.64	4.03	2.41	0.77	31.48
1914	0.98	0.15	1.28	3.10	4.00	2.69	2.18	6.05	1.62	1.55	1.08	1.13	25.81
1915	2.34	1.77	0.30	0.64	2.41	2.57	2.44	5.90	1.78	4.44	1.93	1.23	27.75
1916	2.69	1.05	0.50	3.40	5.69	5.83	1.78	3.47	2.15	1.41	1.83	1.49	31.29
1917	0.72	0.95	1.57	2.92	3.74	7.07	3.16	1.99	1.82	4.37	0.36	0.46	29.13
1918	0.19	0.91	2.09	2.08	4.10	3.38	4.21	2.25	3.60	3.39	2.25	1.78	30.23
Averages	1.28	1.15	1.56	2.38	3.13	3.61	3.53	3.37	2.52	2.60	1.76	1.26	28.40

TOTAL PRECIPITATION, RAINFALL AND SNOW REDUCED TO EQUIVALENT RAINFALL, 1917–18.

1917	1.97	1.90	2.77	2.92	3.74	7.07	3.16	1.99	1.82	4.37	0.71	3.03	35.45
1918	1.74	1.59	2.82	2.38	4.10	3.38	4.21	2.25	3.60	3.39	2.25	2.68	34.39
Averages	1.85	1.74	2.79	2.65	3.92	5.22	3.68	2.12	2.71	3.88	1.48	2.85	24.92

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